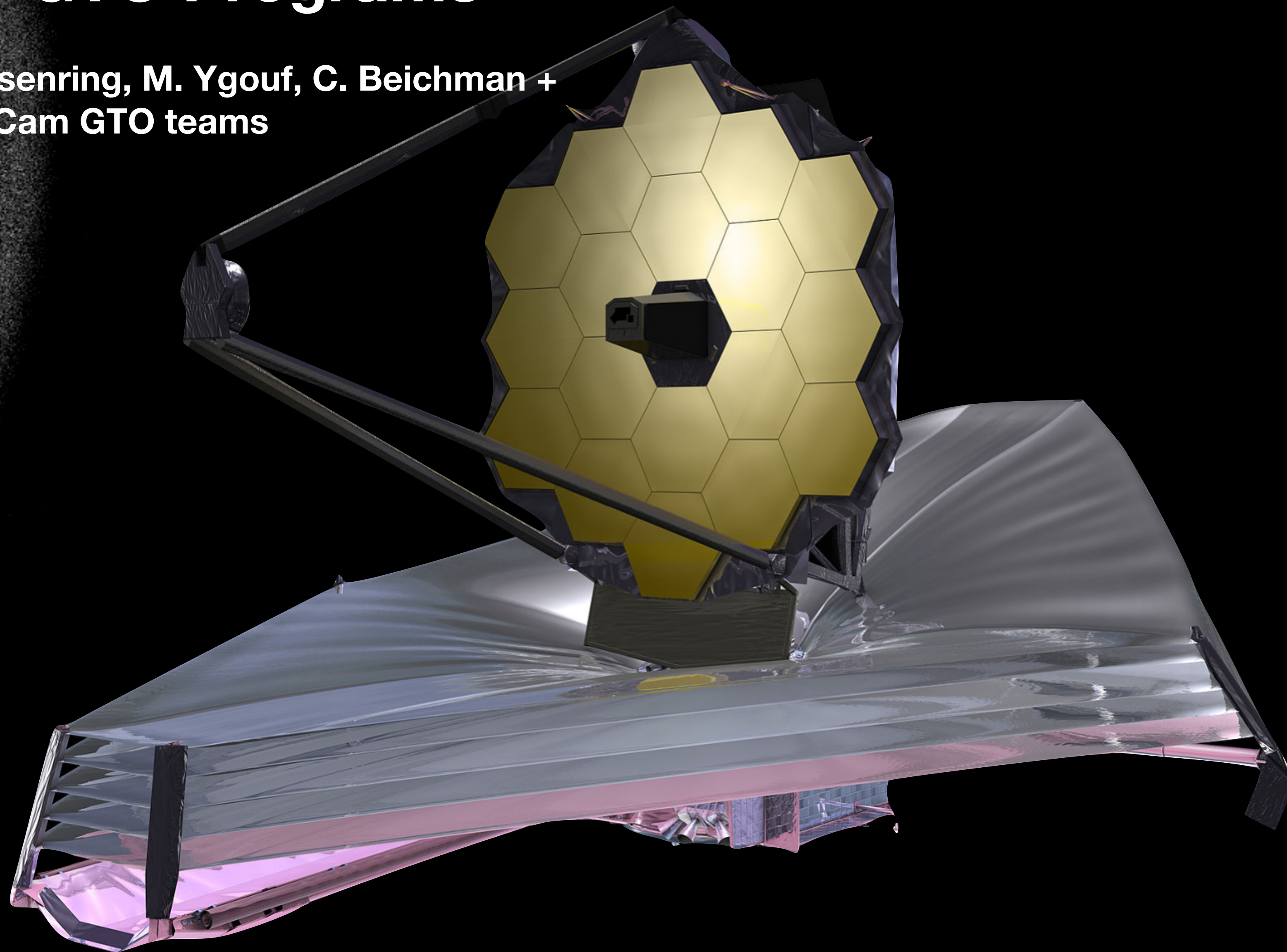
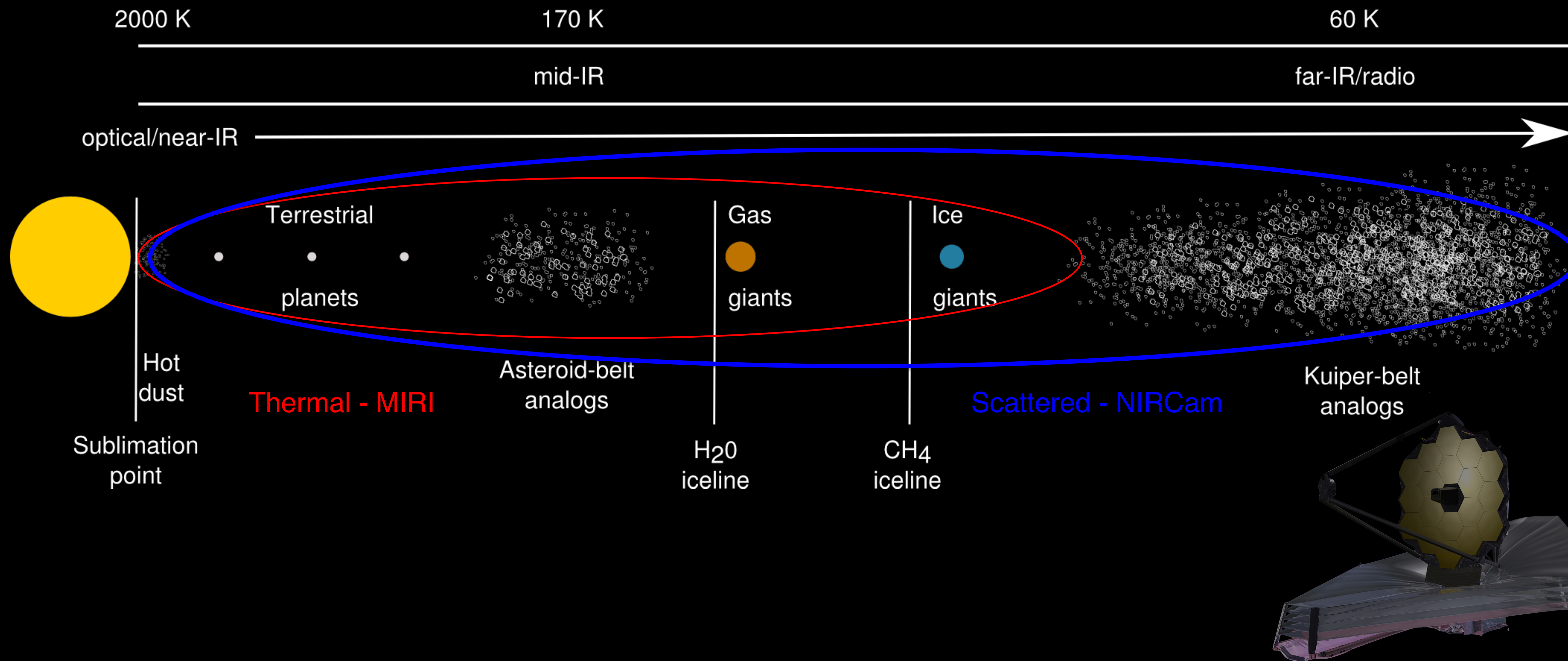


The JWST Debris Disk Spatially Resolved Imaging GTO Programs

András Gáspár, M. Rieke, G. Rieke, J. Leisenring, M. Ygouf, C. Beichman +
the JWST MIRI and NIRCам GTO teams



Debris Disk architecture



THE JWST GTO DEBRIS DISK PROGRAMS

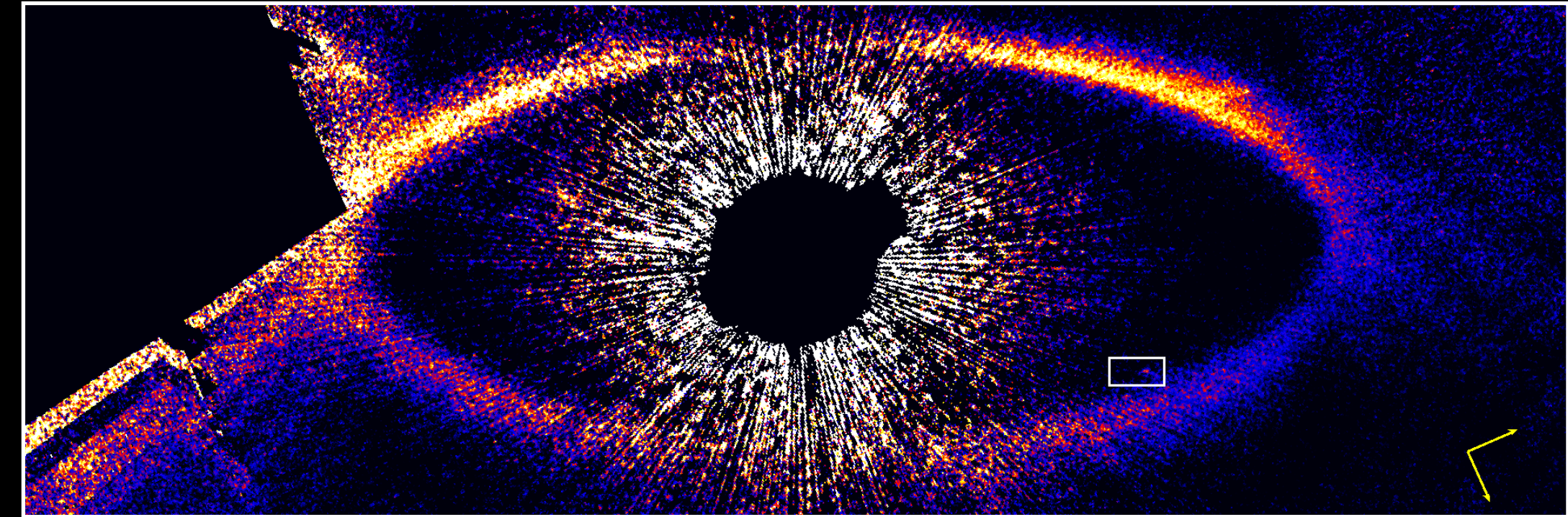
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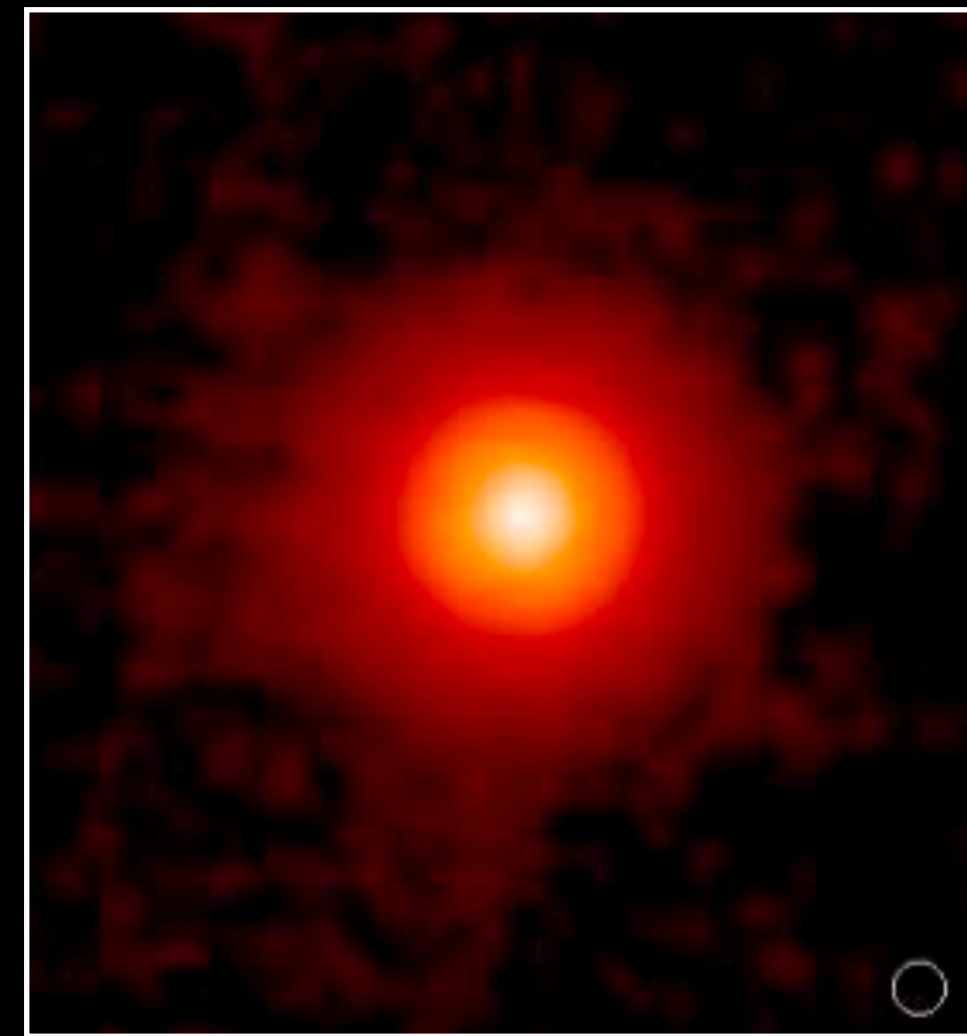
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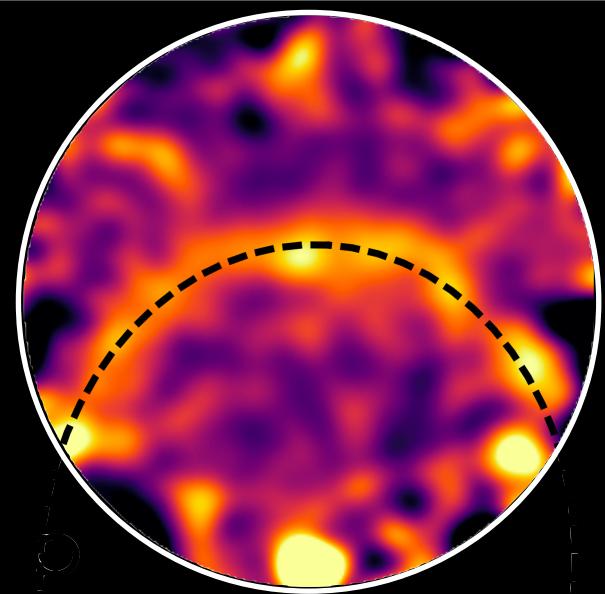
Plus, additional programs to image the HR8799 system, which also has a disk!



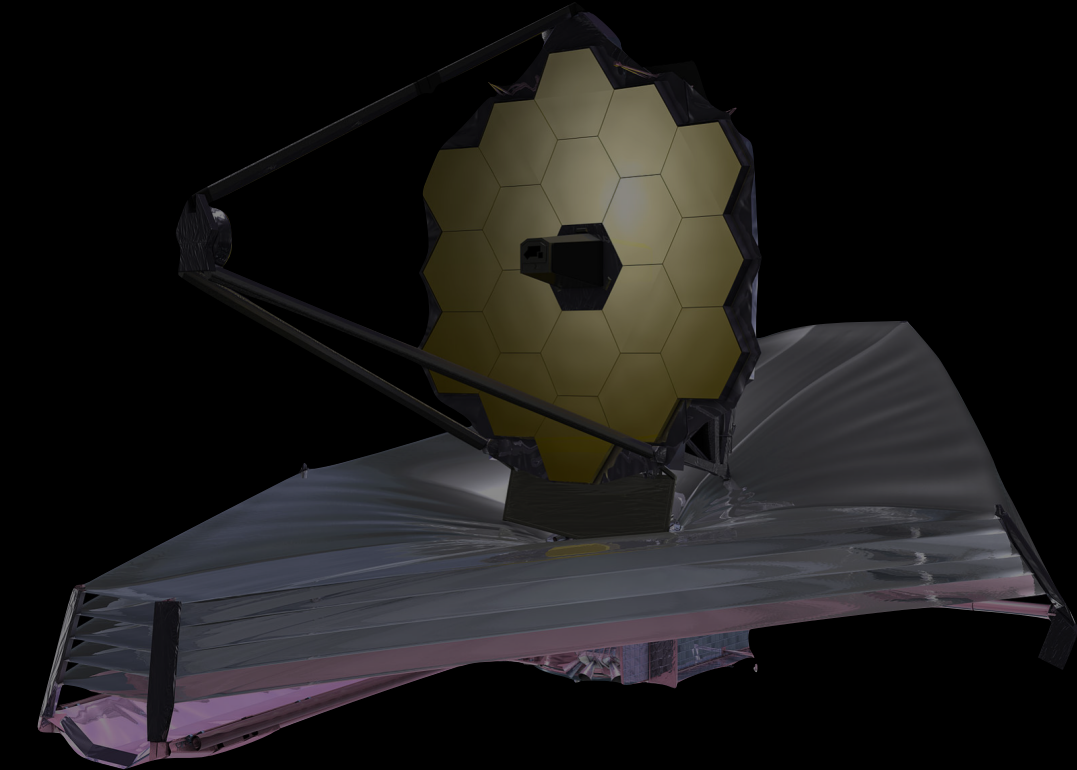
Gáspár et al. (submitted)



Su et al. (2005)



Booth et al. (2017)



THE JWST GTO DEBRIS DISK PROGRAMS

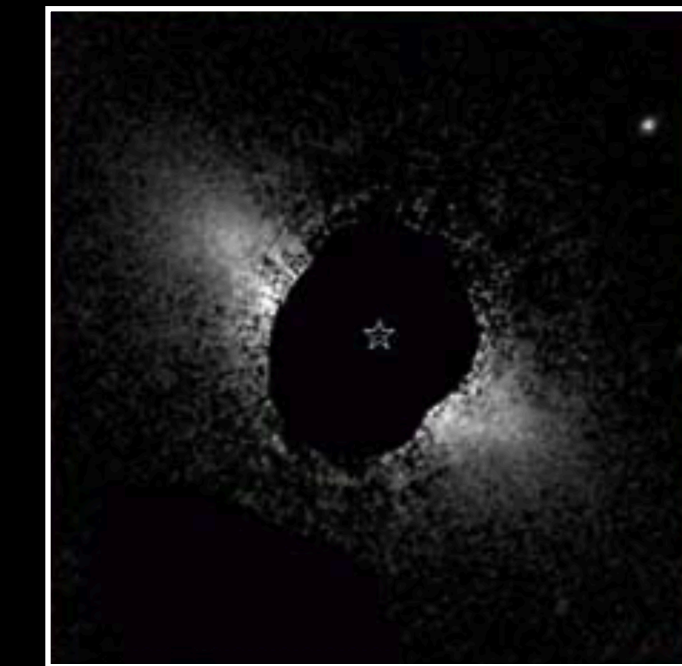
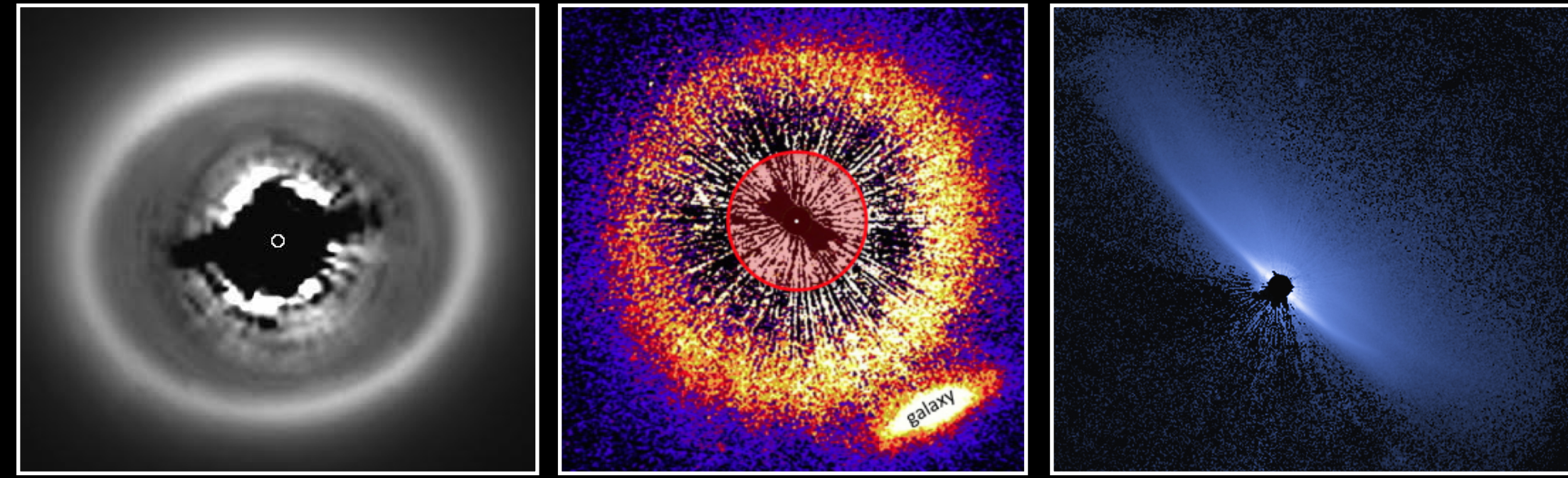
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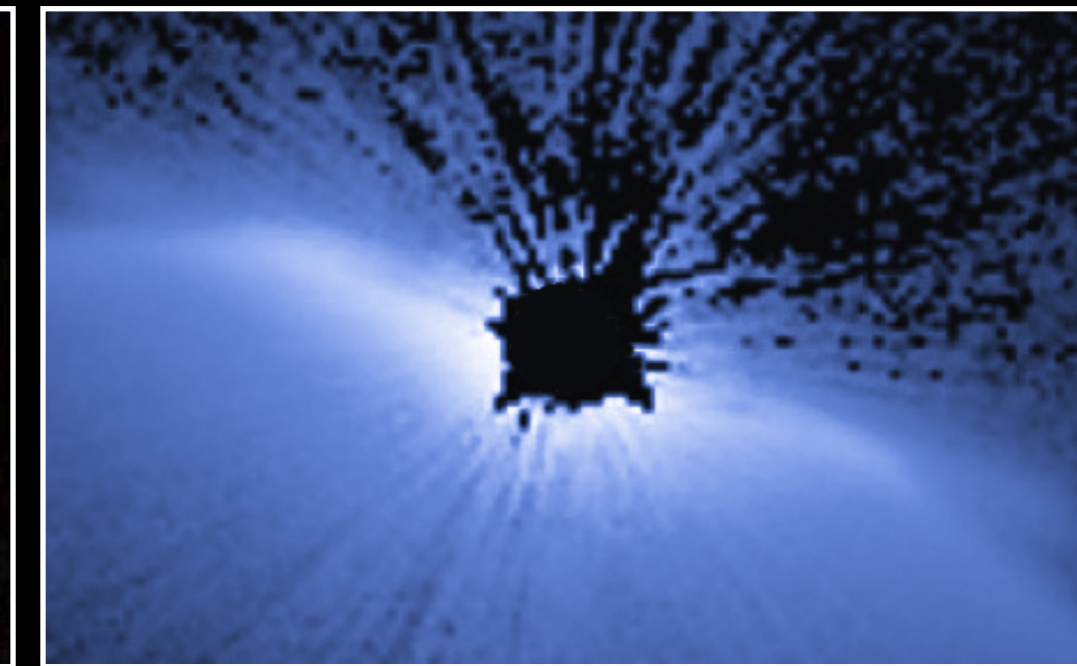
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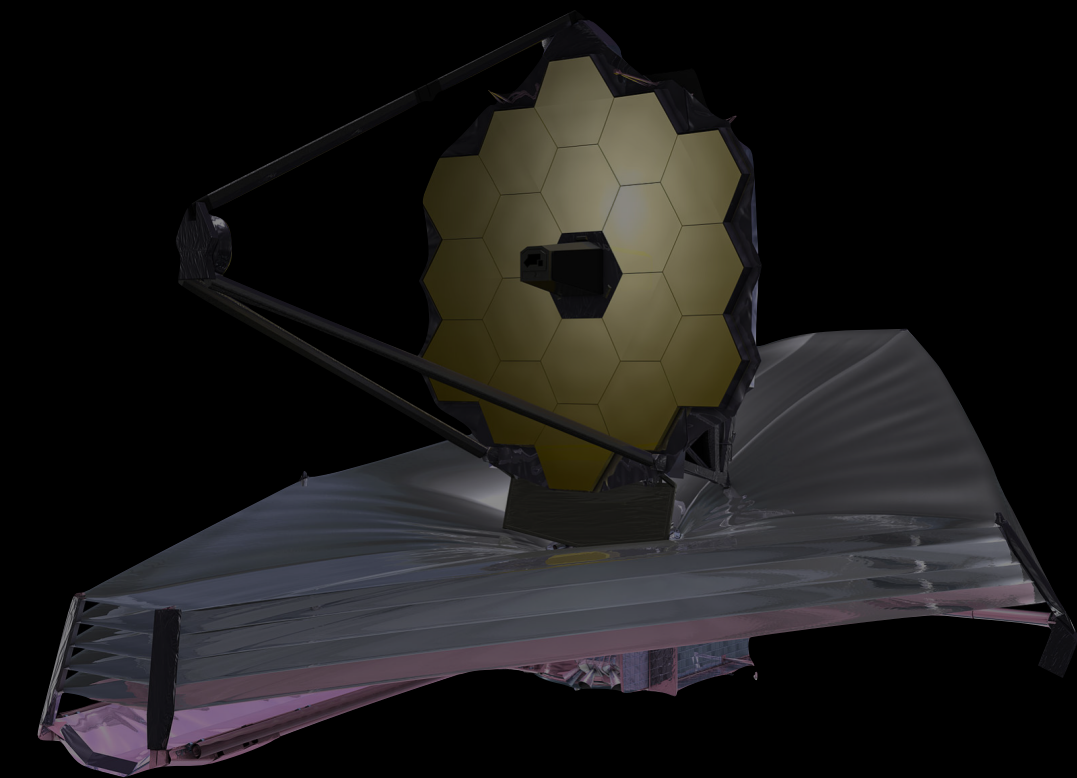
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Stapelfeldt et al. (2007)



Schneider et al. (2014)



THE JWST GTO DEBRIS DISK PROGRAMS

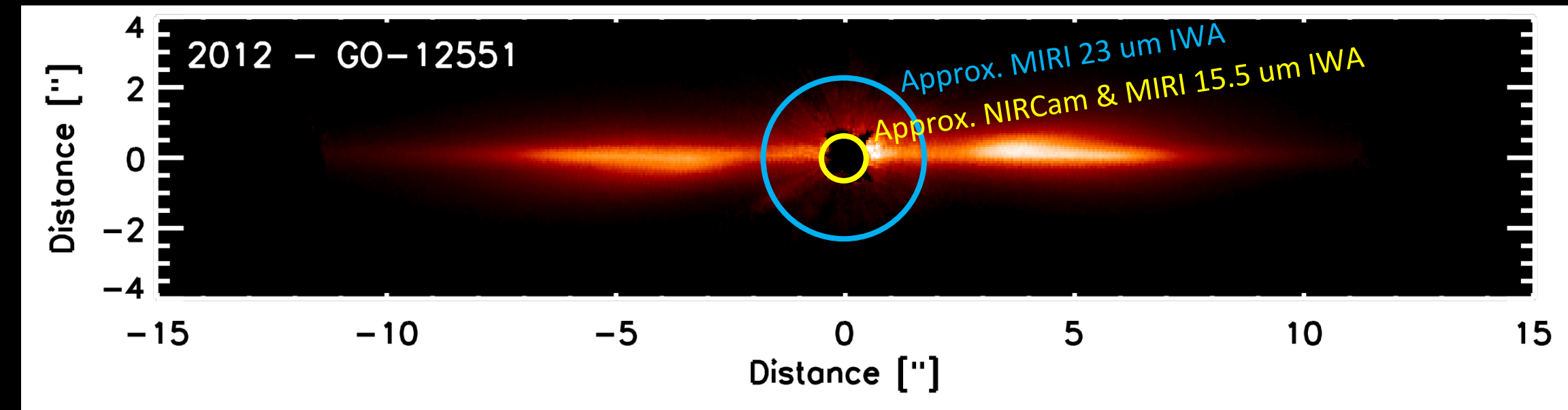
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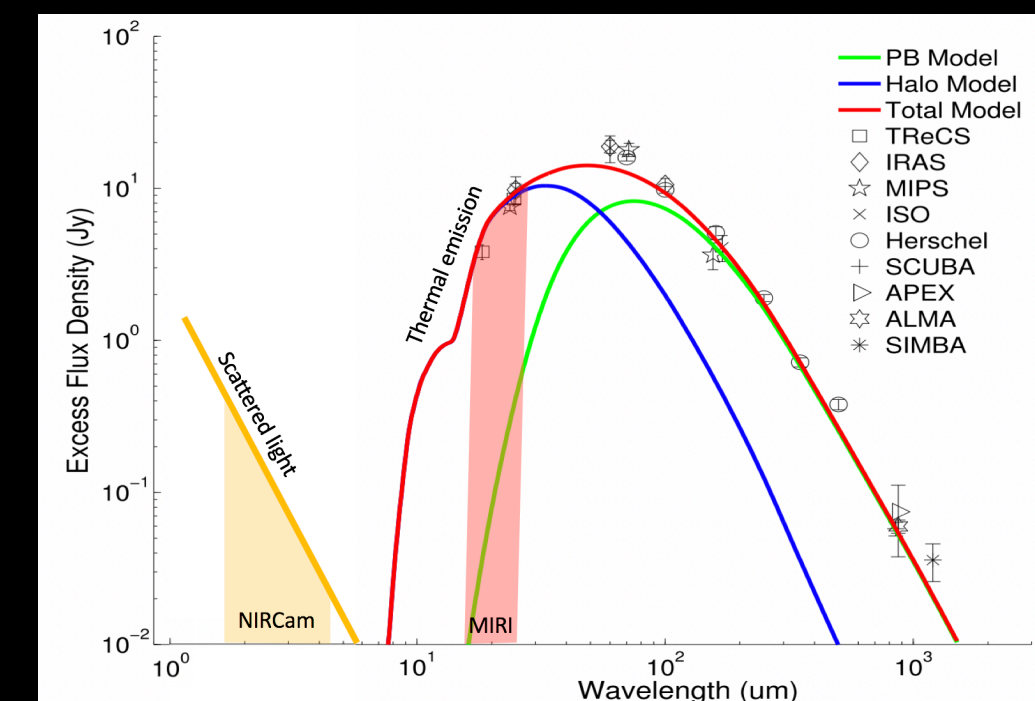
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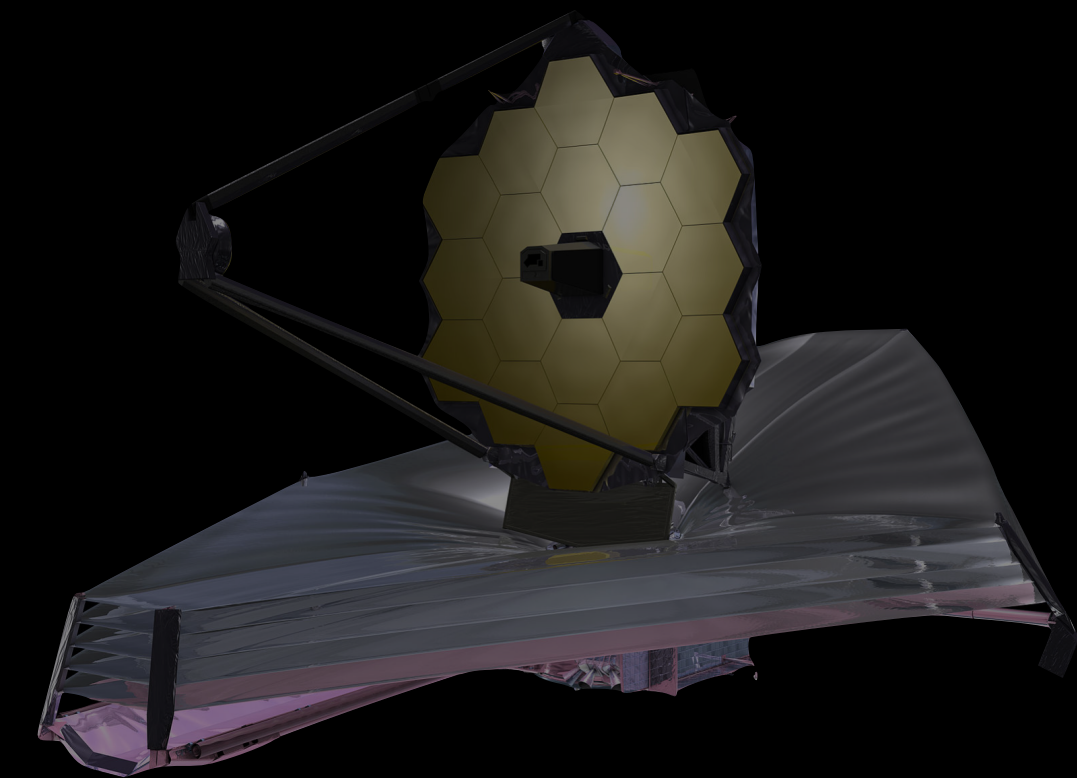
C. Stark, L. Pueyo, M. Perrin, R. Soummer, M. Mountain, A. Rajan, M. Clampin

Goal: Spatially resolve one of the brightest debris disks from 1.8 – 23 μm

- Span the transition from scattered light to thermal emission to inform dust size-distribution and composition
- Search for spatial variations
- Search for wide-separation planets (Beta Pic b not expected to be observed)



Adapted from Ballering et al. (2016)



THE JWST GTO DEBRIS DISK PROGRAMS

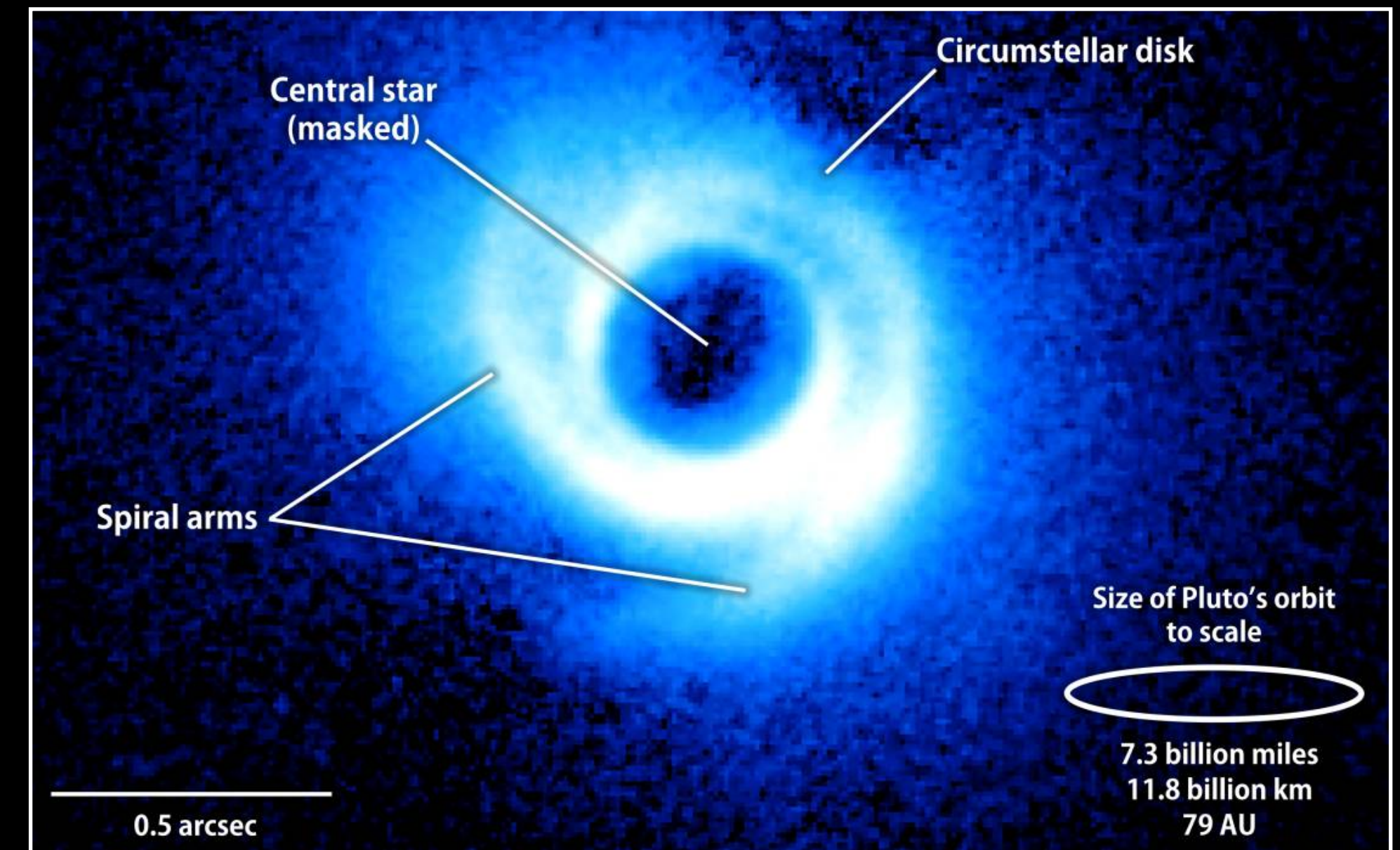
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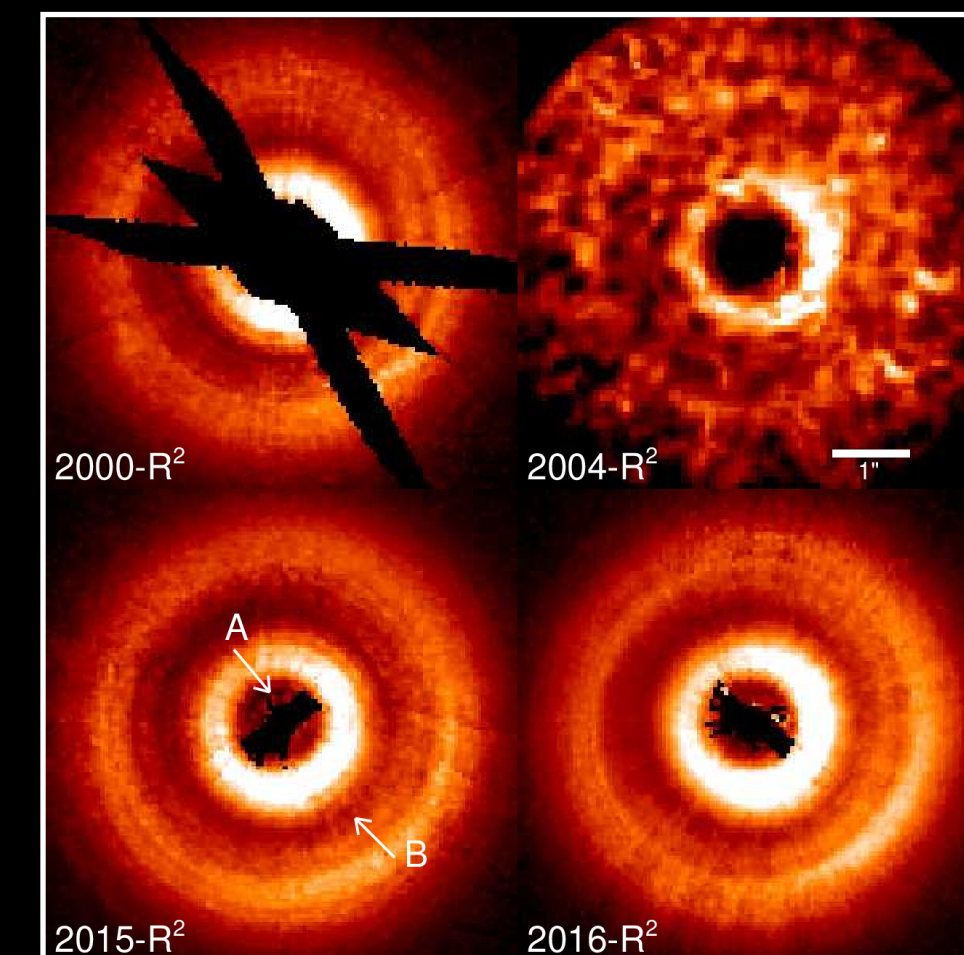
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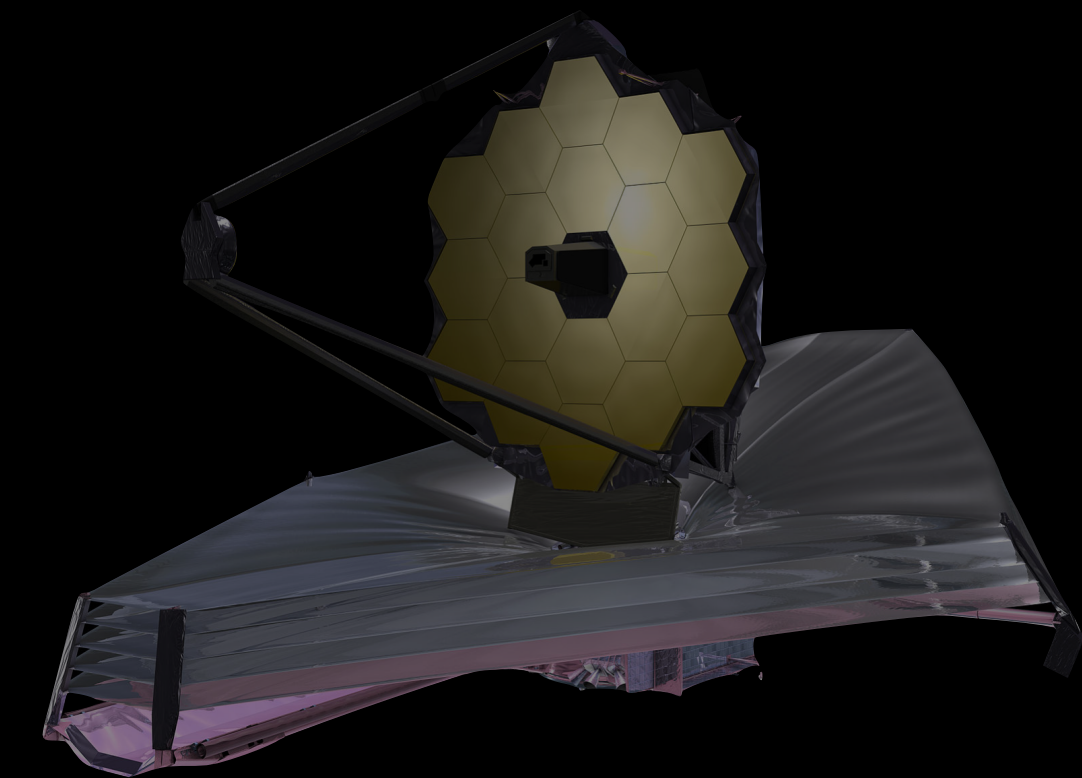
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Muto et al. (2012)



Debes et al. (2017)



THE JWST GTO DEBRIS DISK PROGRAMS

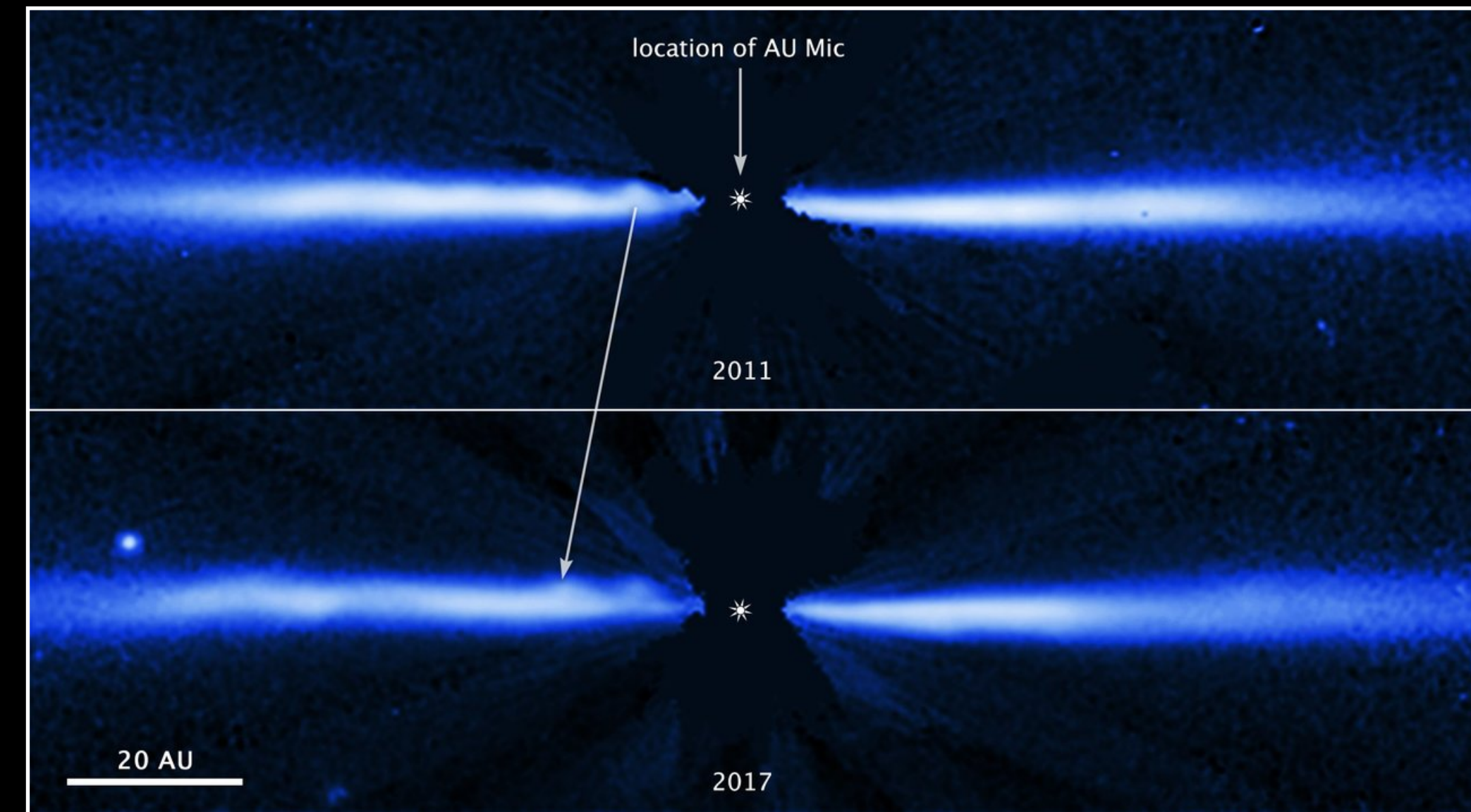
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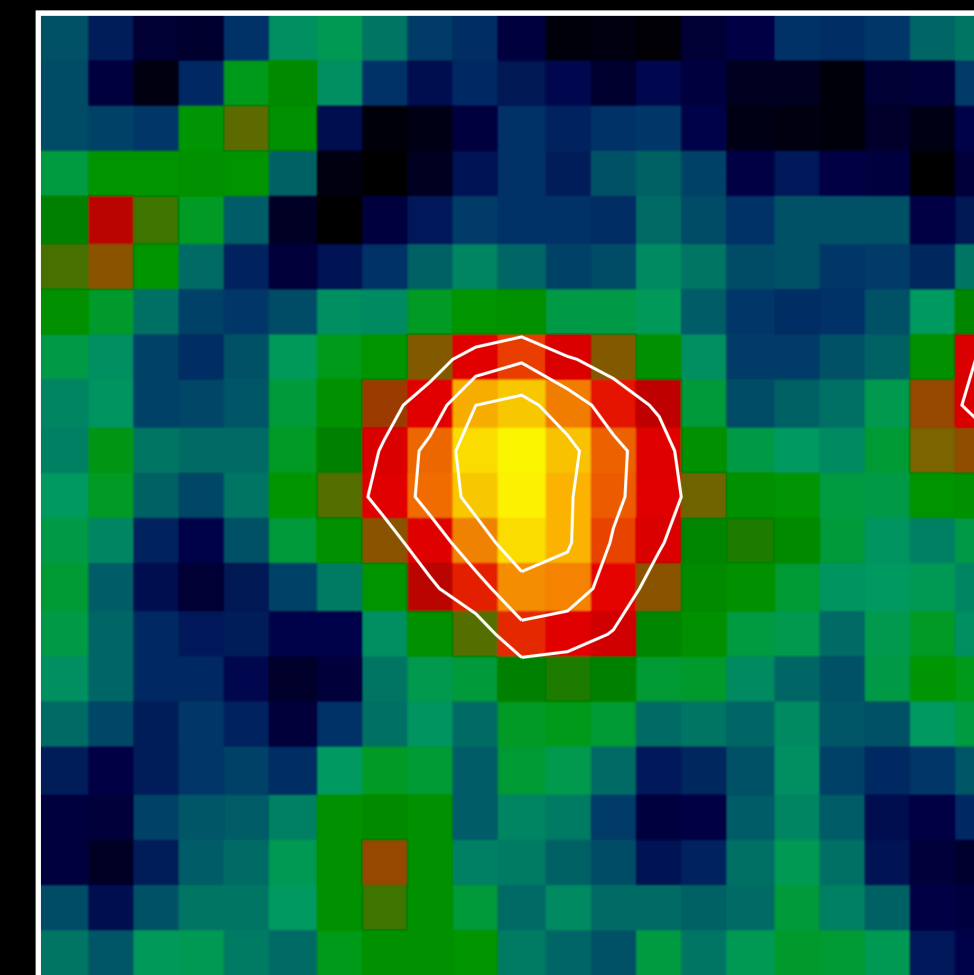
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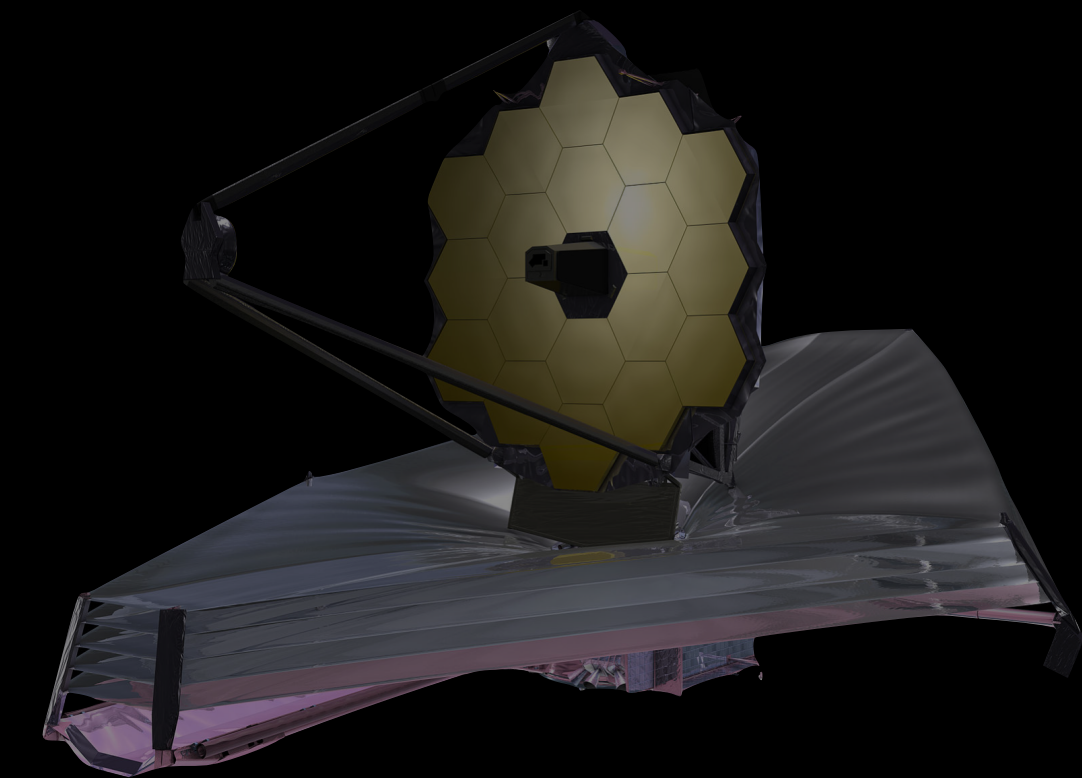
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Boccaletti et al. (2018)



Kennedy et al. (2014)



THE JWST GTO DEBRIS DISK PROGRAMS

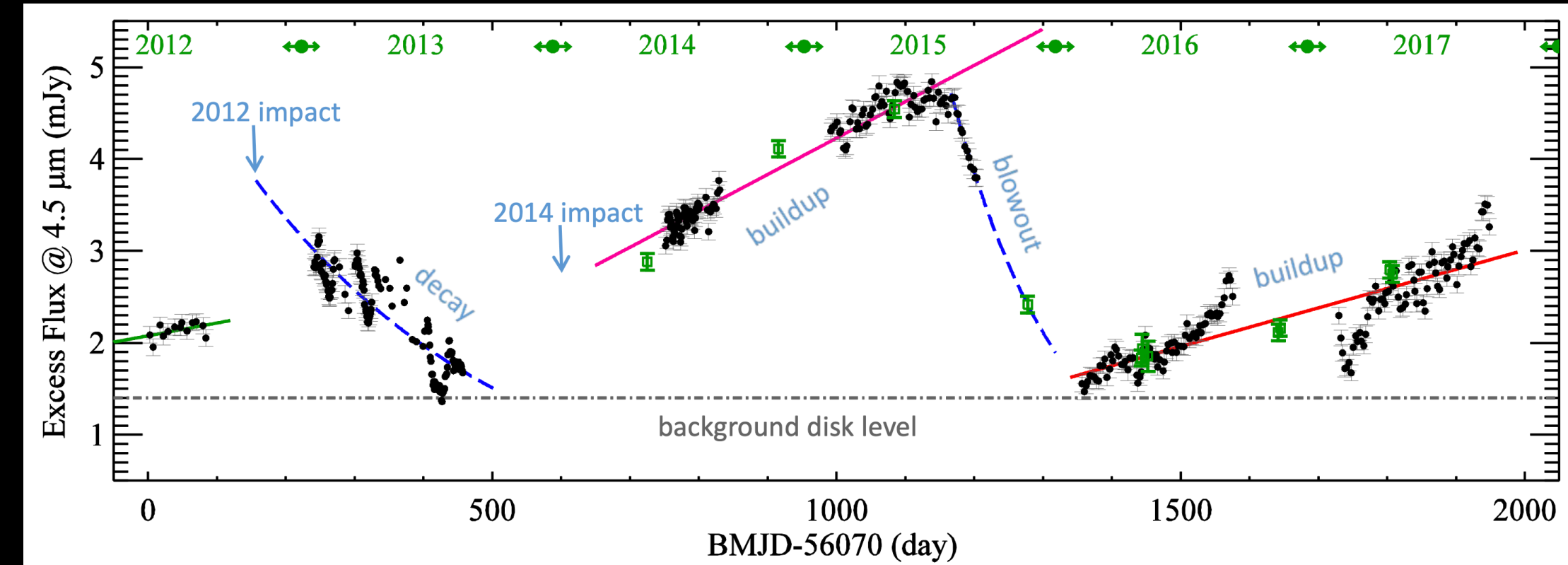
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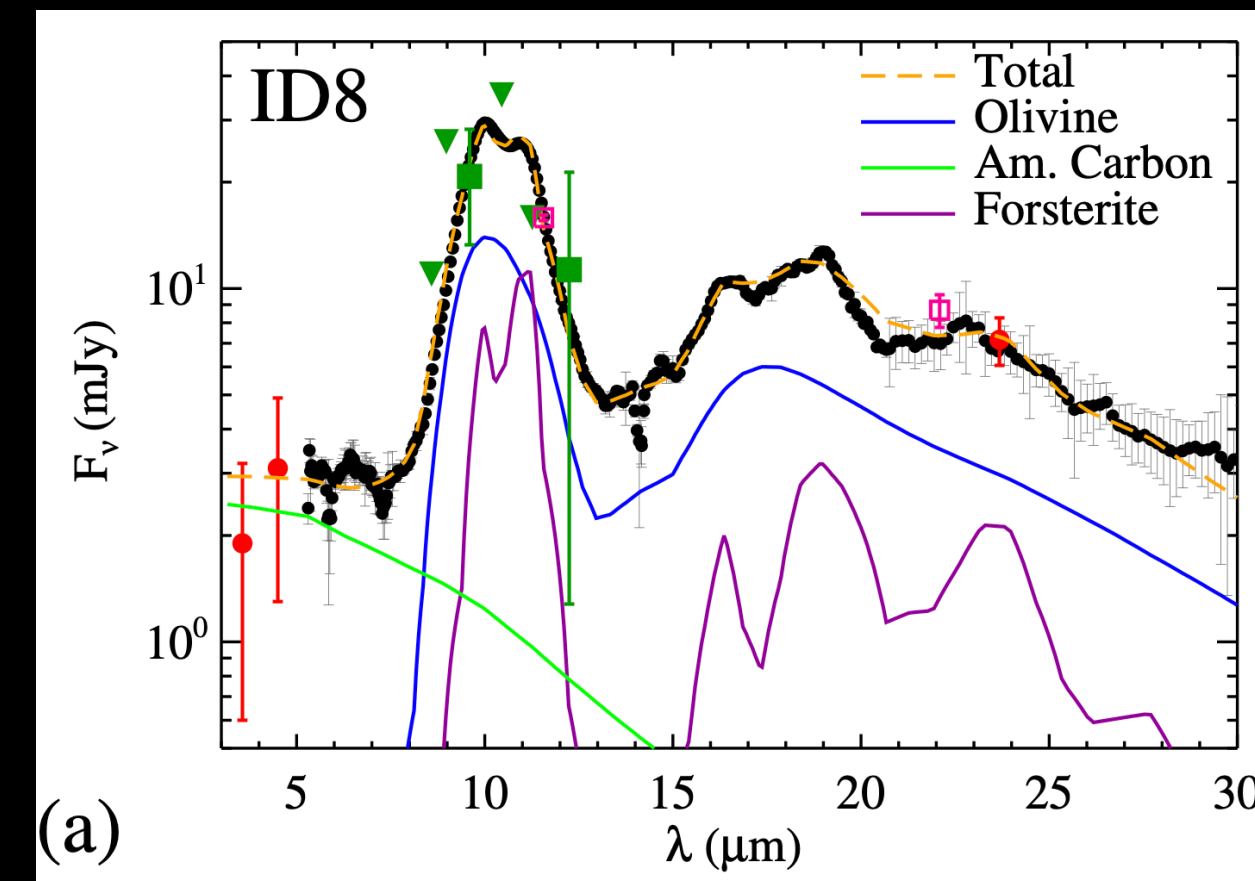
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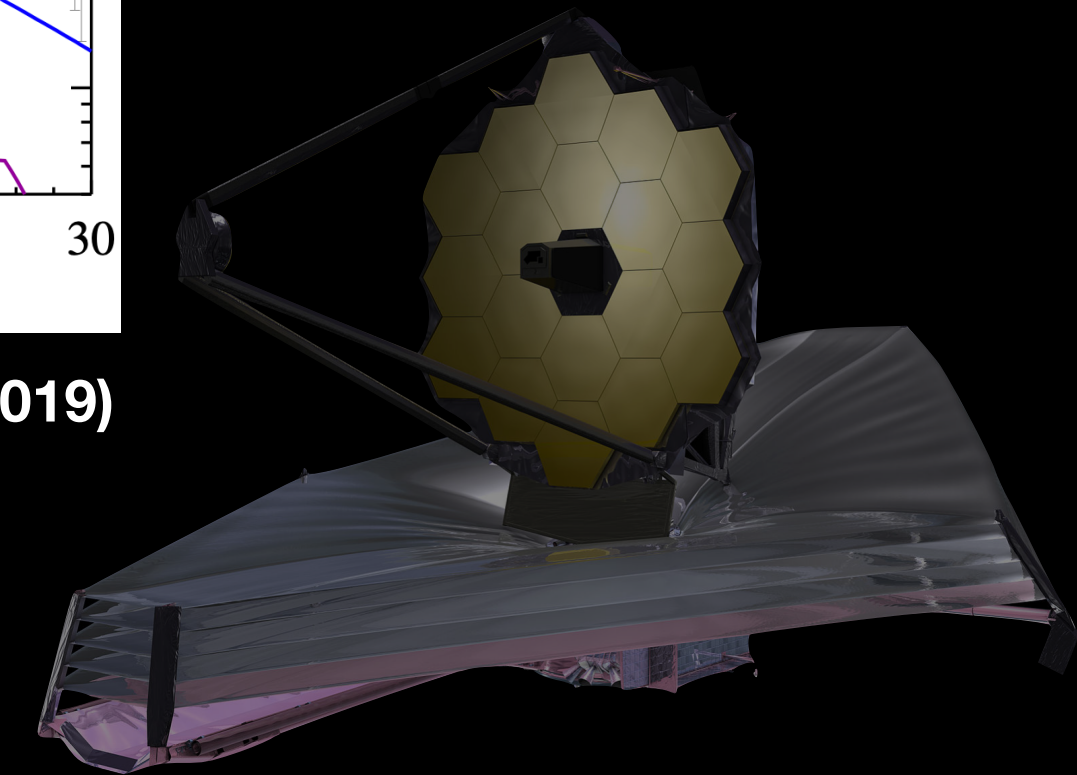
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Su et al. (2019)



Su et al. (2019)



THE JWST GTO DEBRIS DISK PROGRAMS

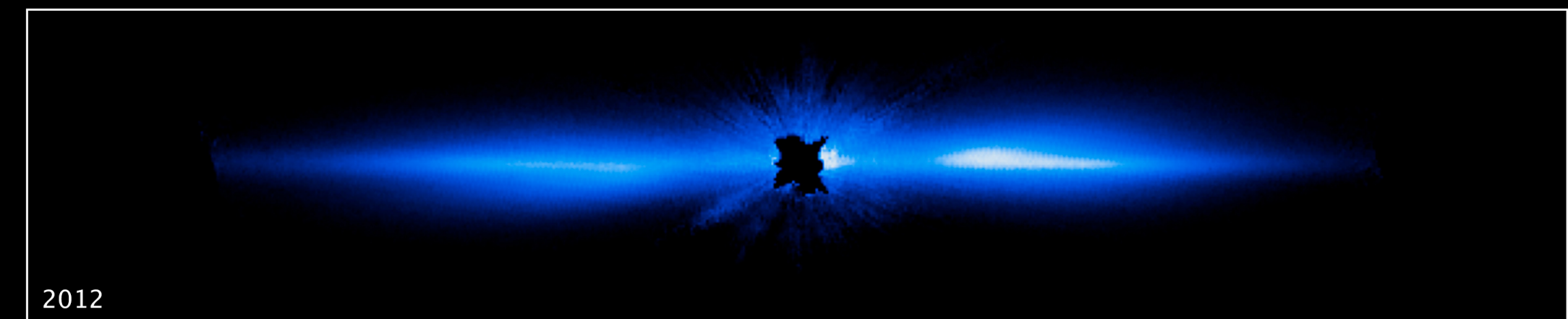
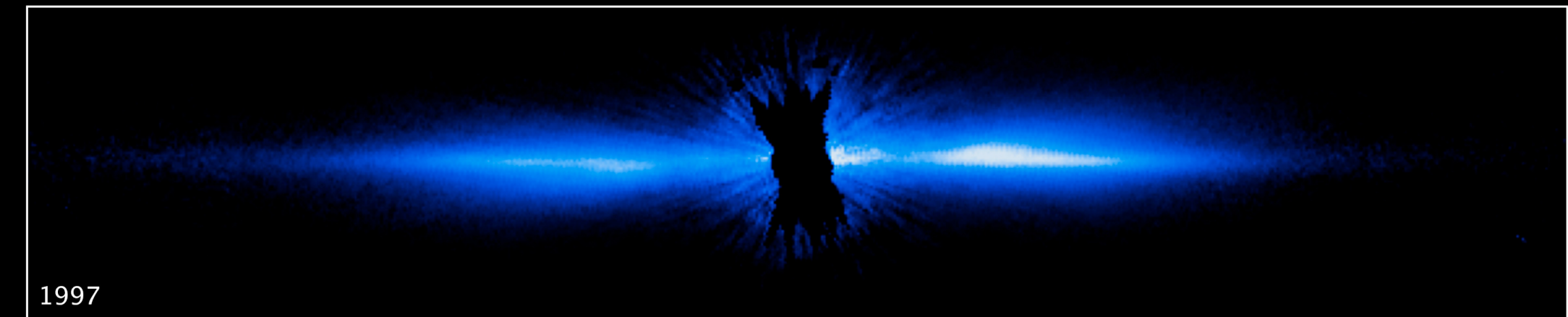
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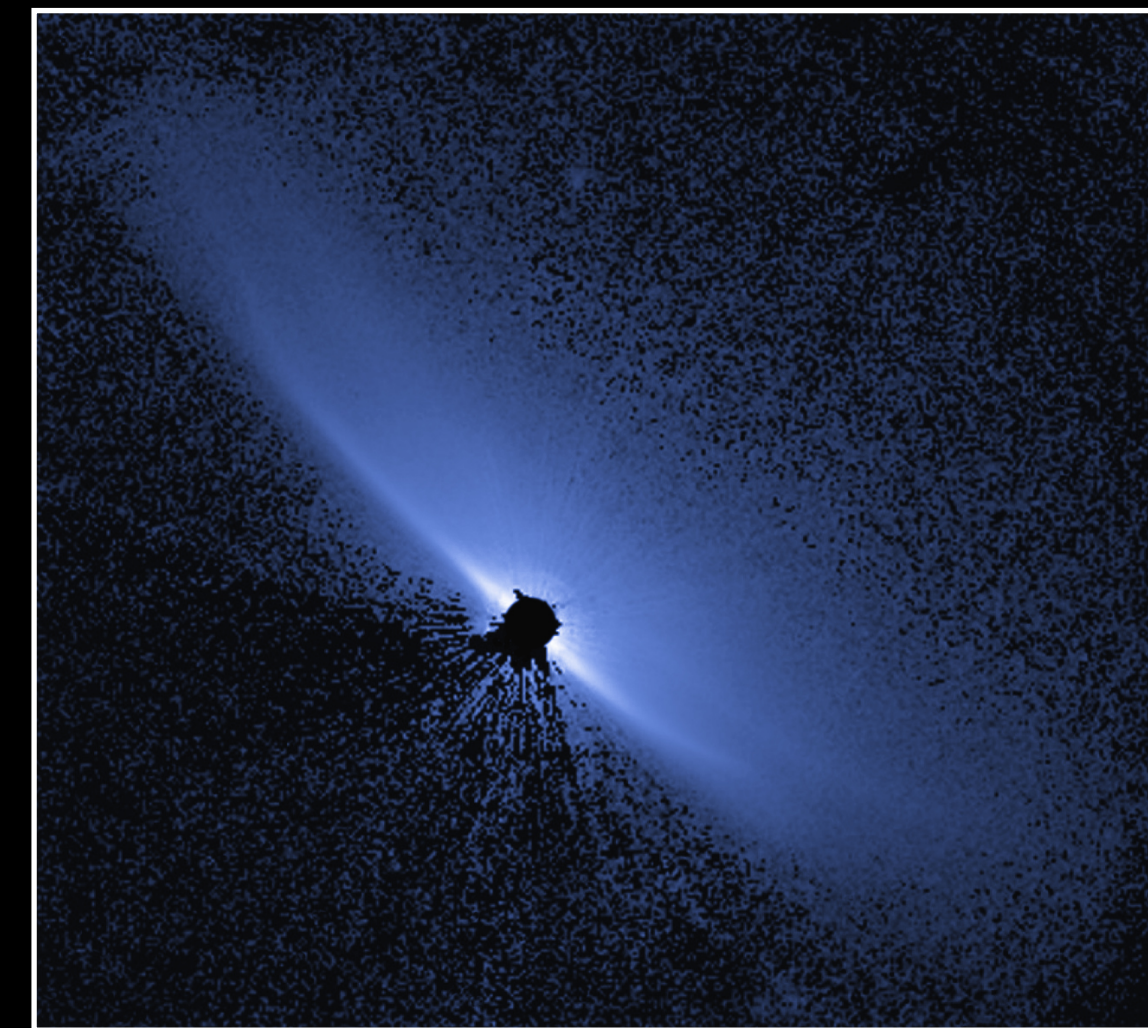
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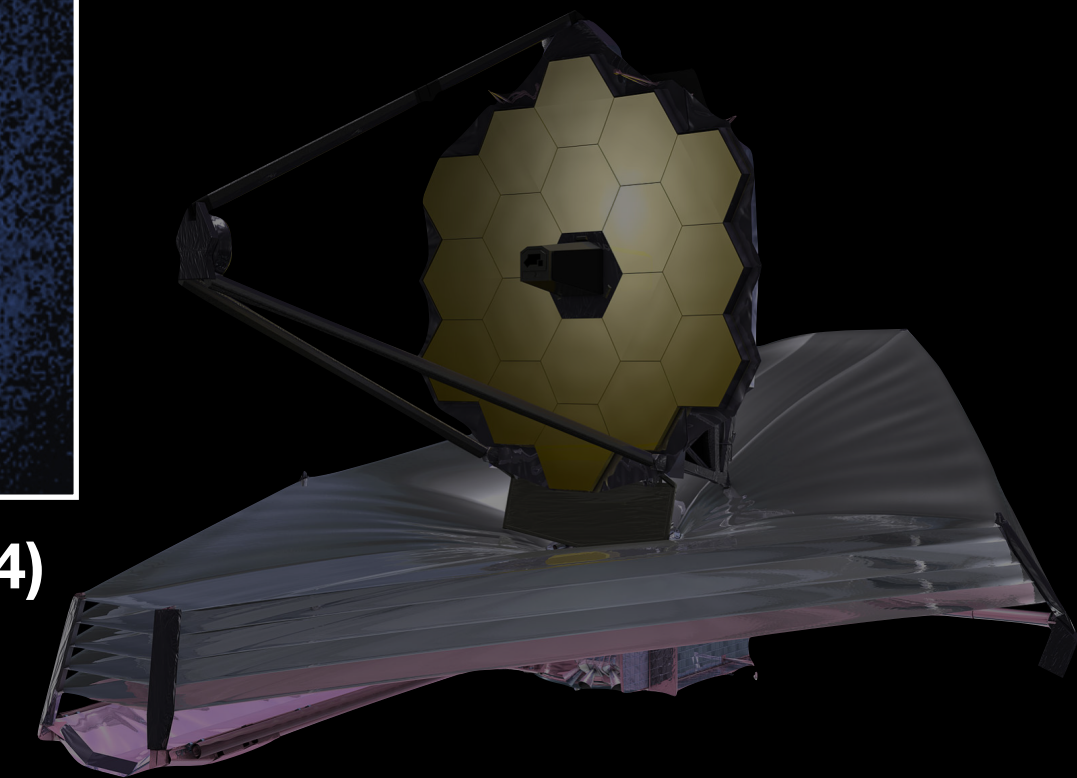
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Heap (1997) and Apai (2012)



Schneider et al. (2014)



THE JWST GTO DEBRIS DISK PROGRAMS

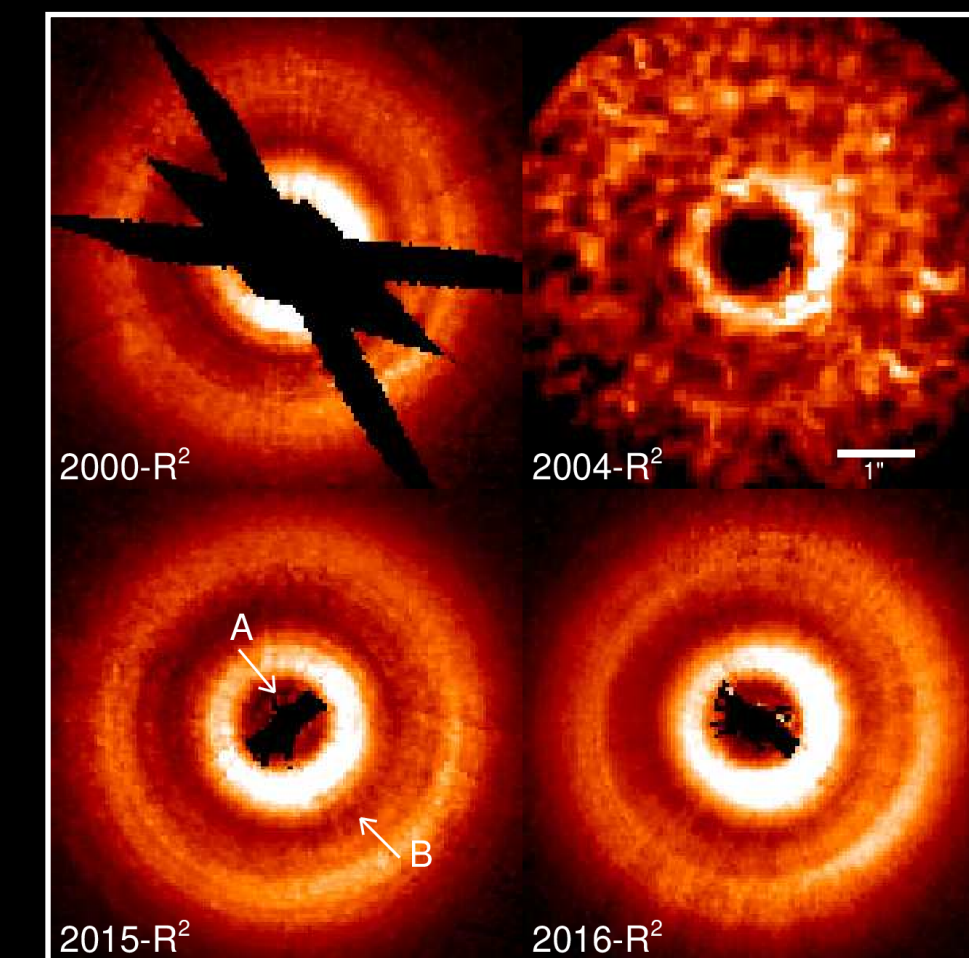
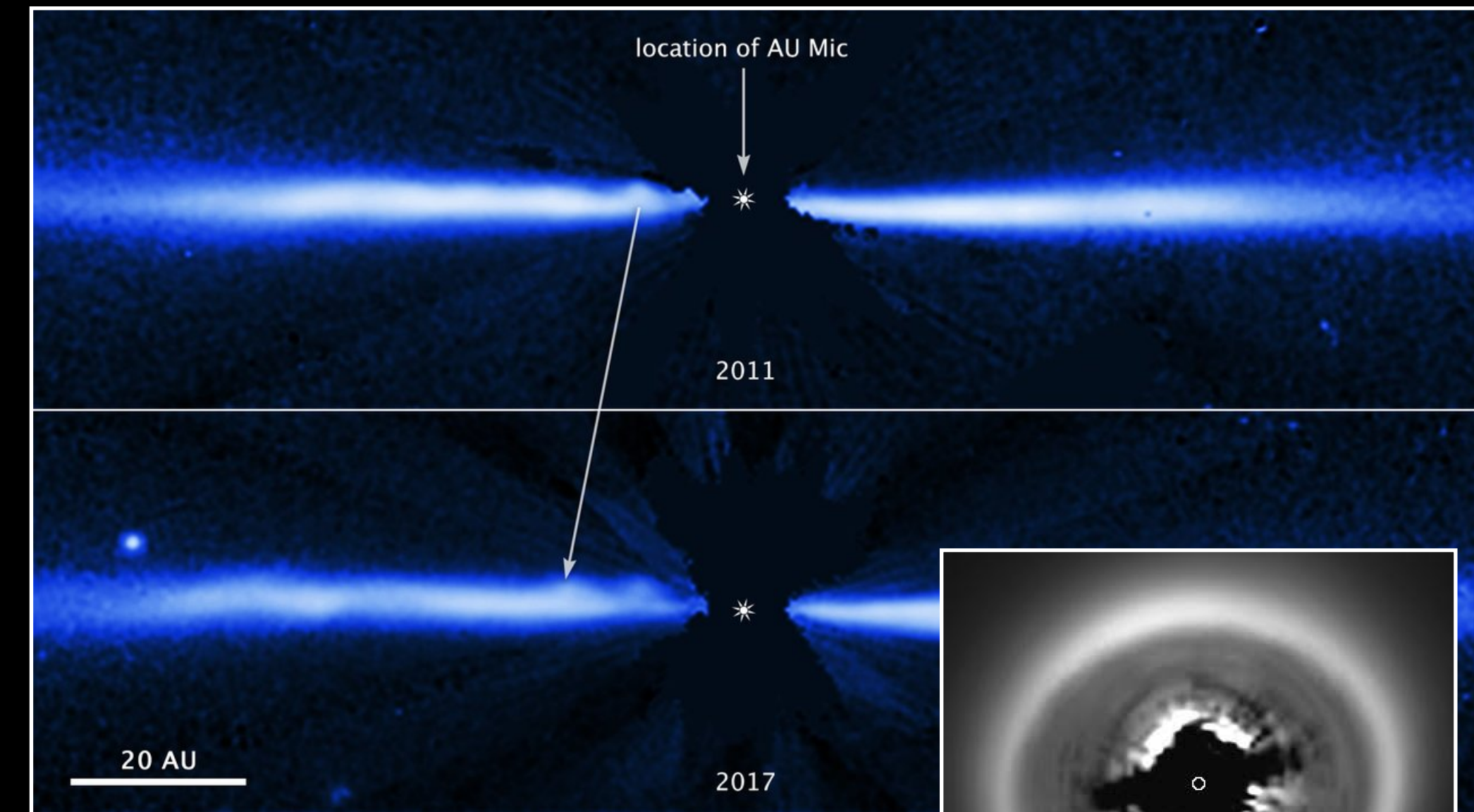
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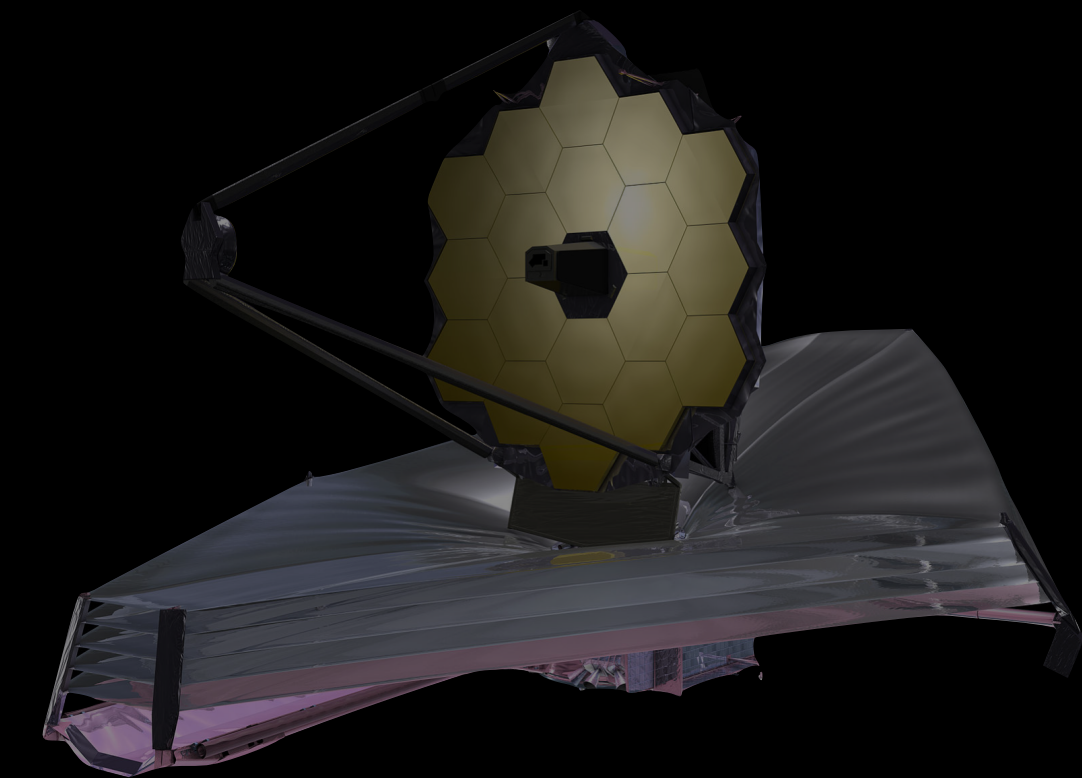
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Debes et al. (2017)



The MIRI GTO Archetypical Disks Program

Program Goals

Goals of the program are to (1) resolve the asteroid belts of the nearest systems and (2) understand the physical processes that form the structures and their evolution history.

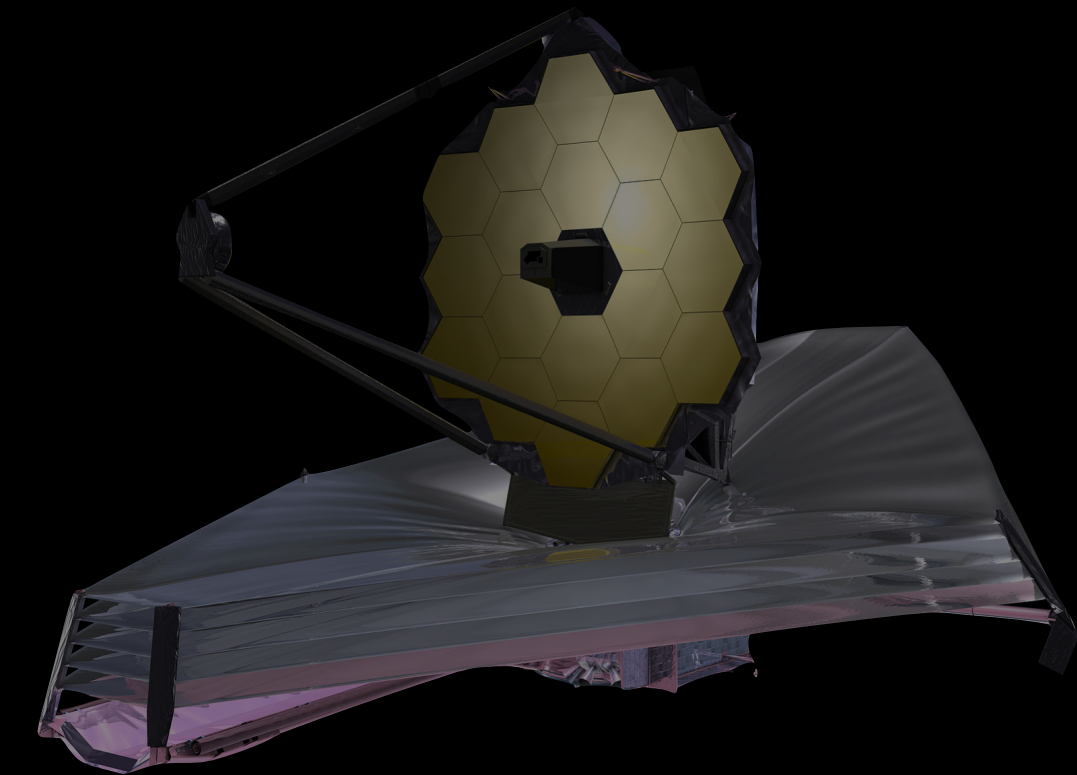
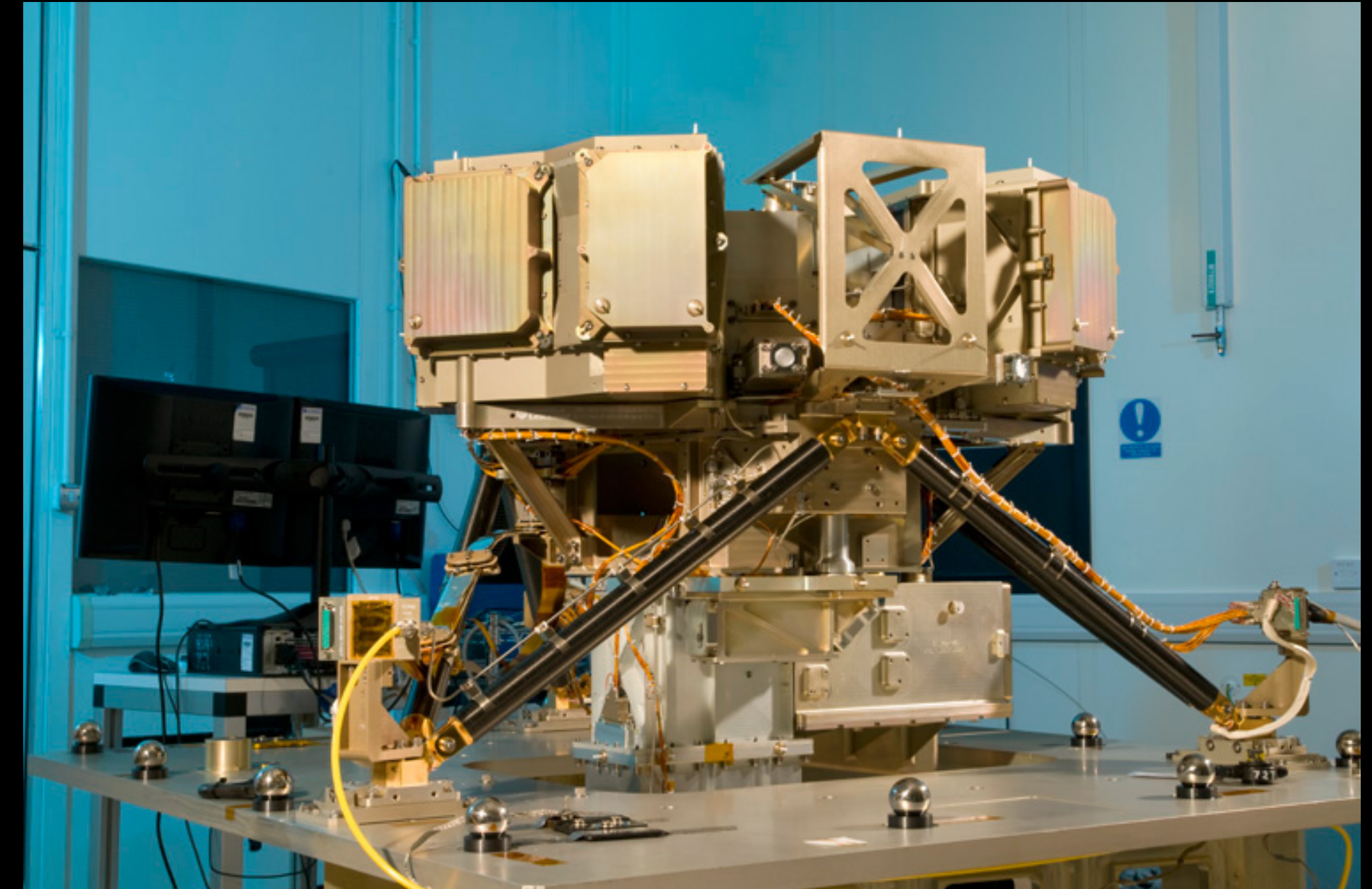
These include:

- Are there shepherding planets?
- Particle size constraints
- Particle spatial locations

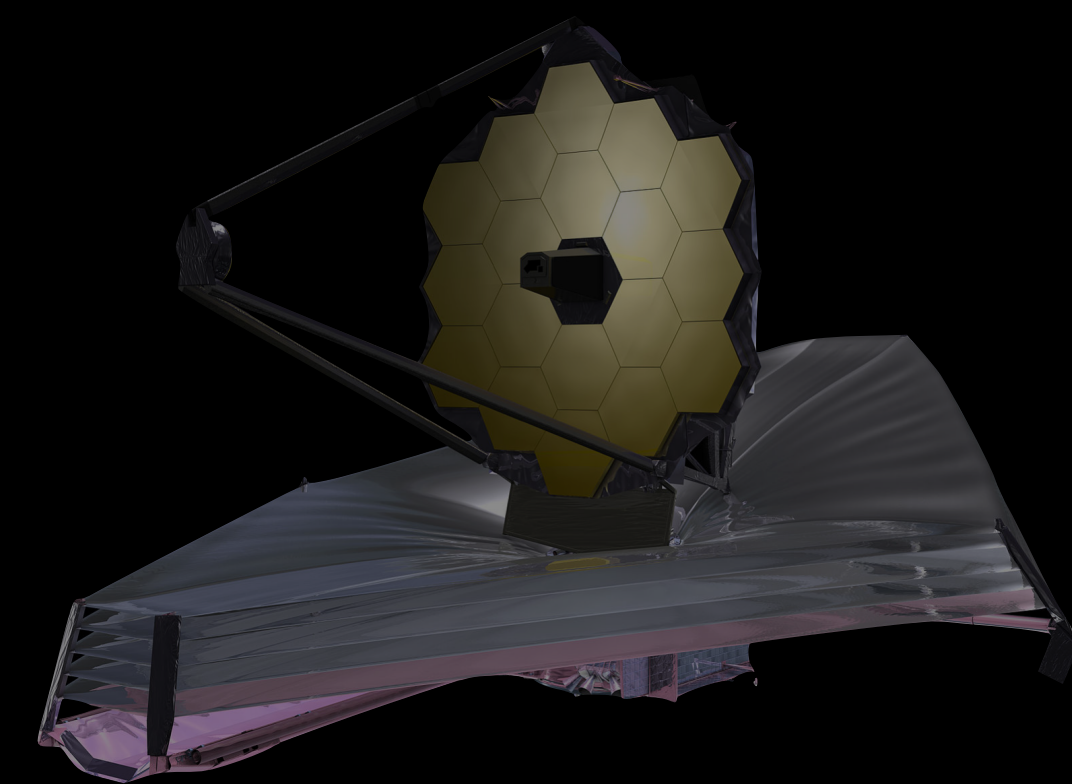
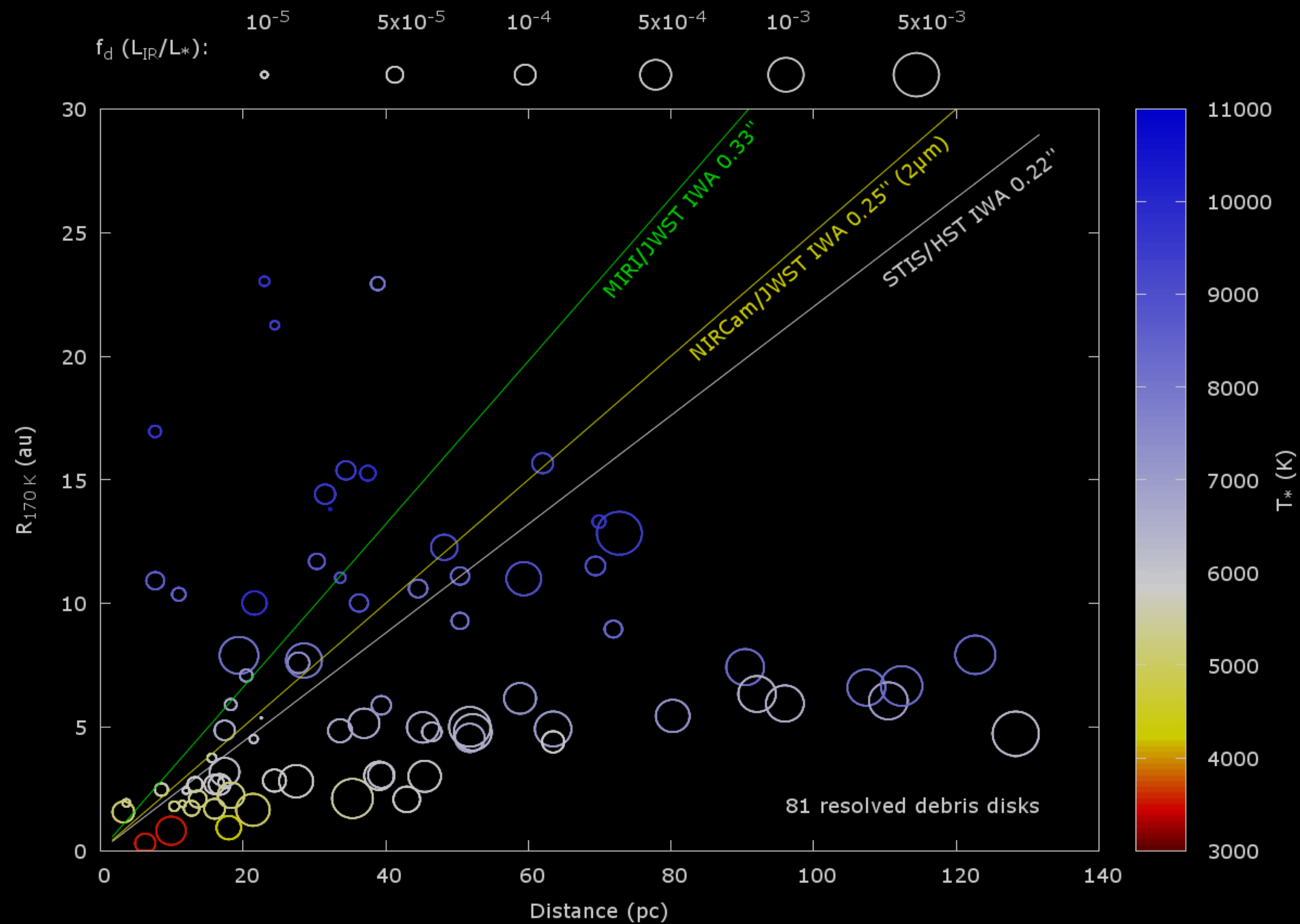
The strength of the effects vary by radial distance:

- Collisions are more destructive closer to the star
- Radiative effects are stronger closer in (PR-drag is $\propto r^2$)

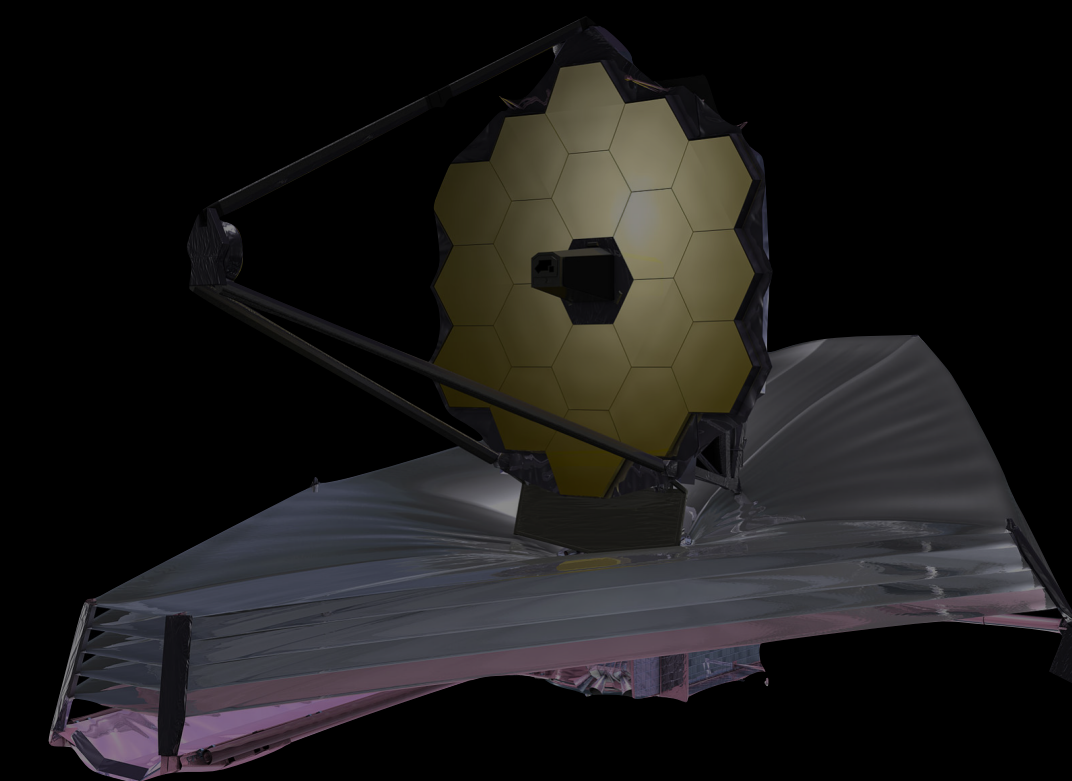
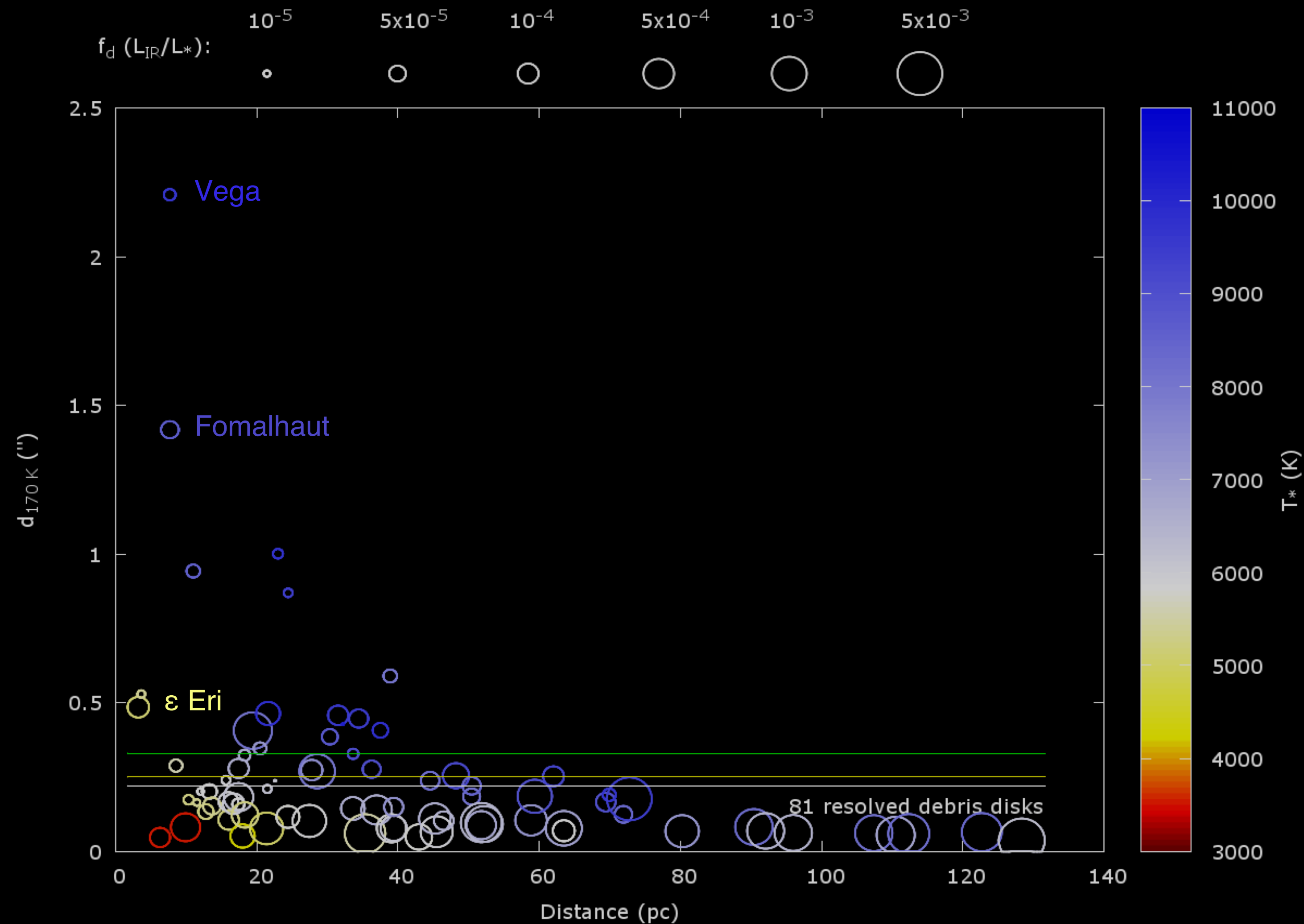
Therefore: high spatial-resolution panchromatic imaging of disks from the iceline to their halos is necessary.



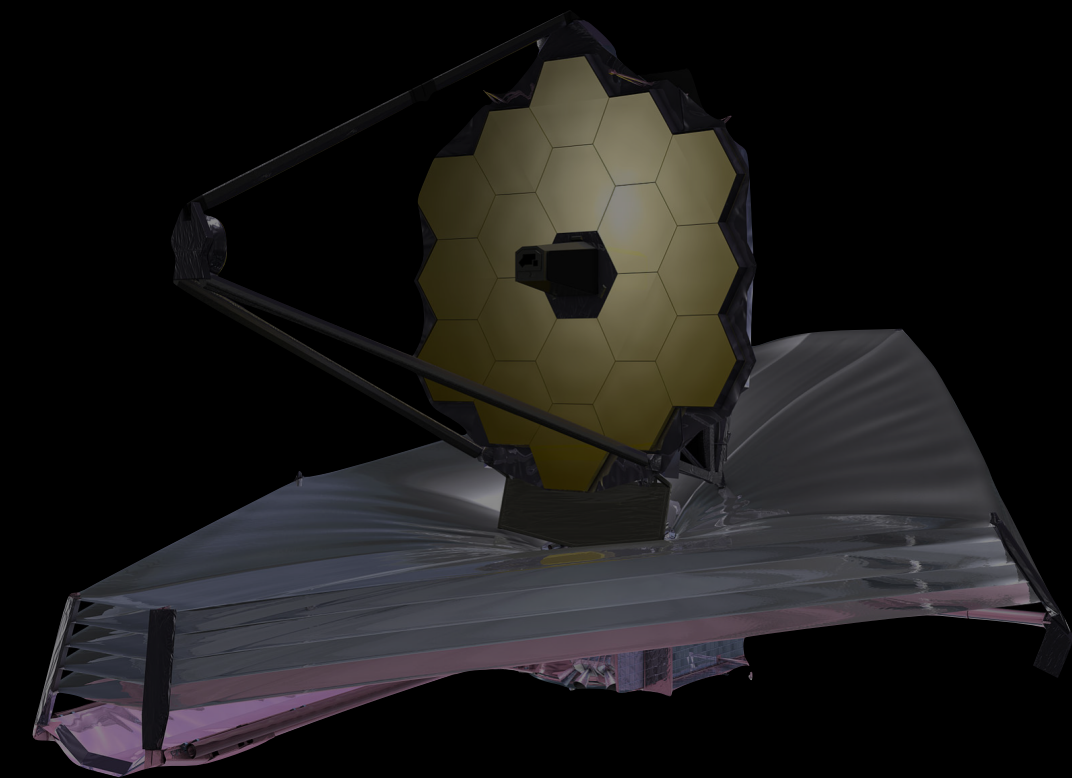
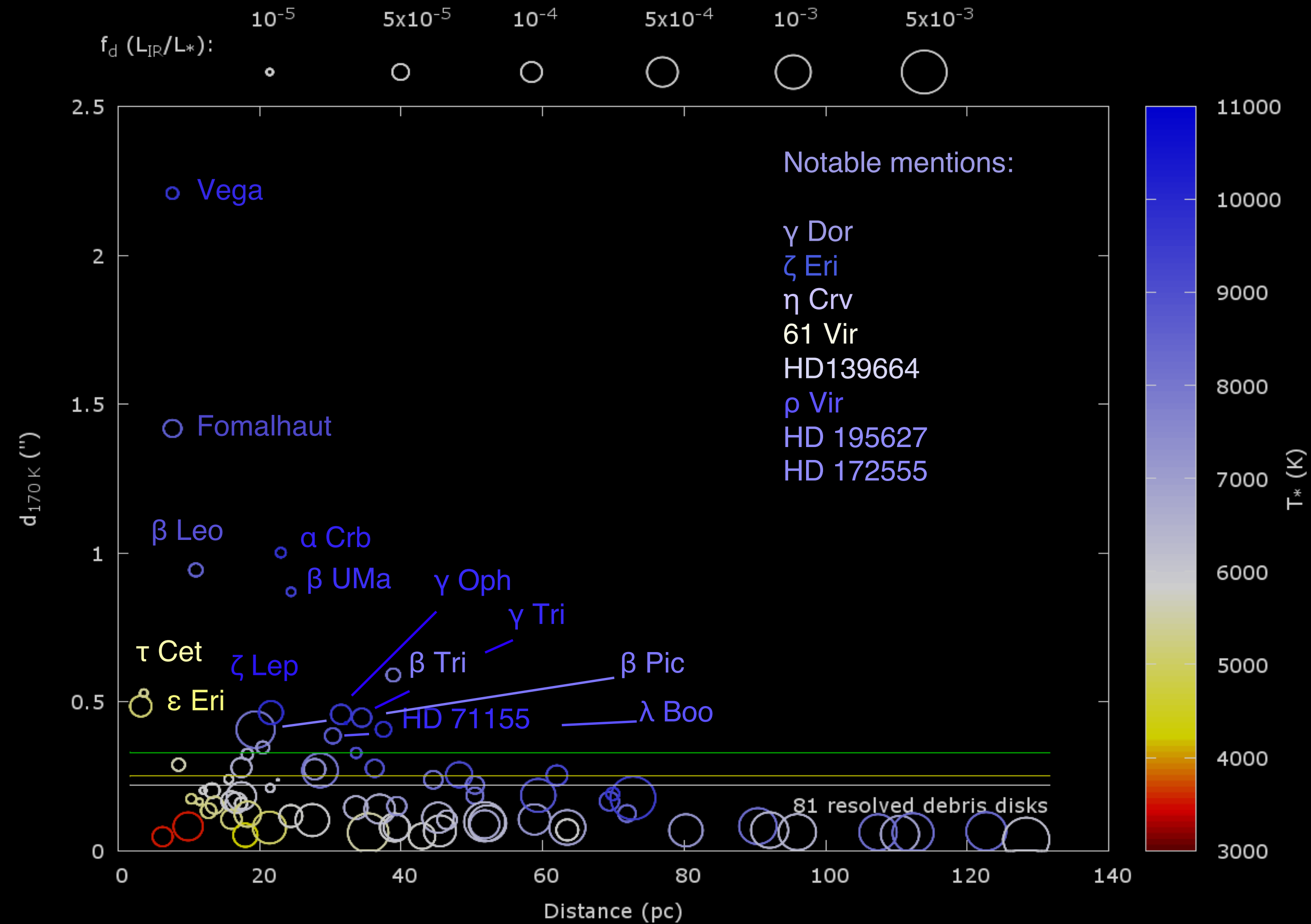
The MIRI GTO Archetypical Disks Program



The MIRI GTO Archetypical Disks Program



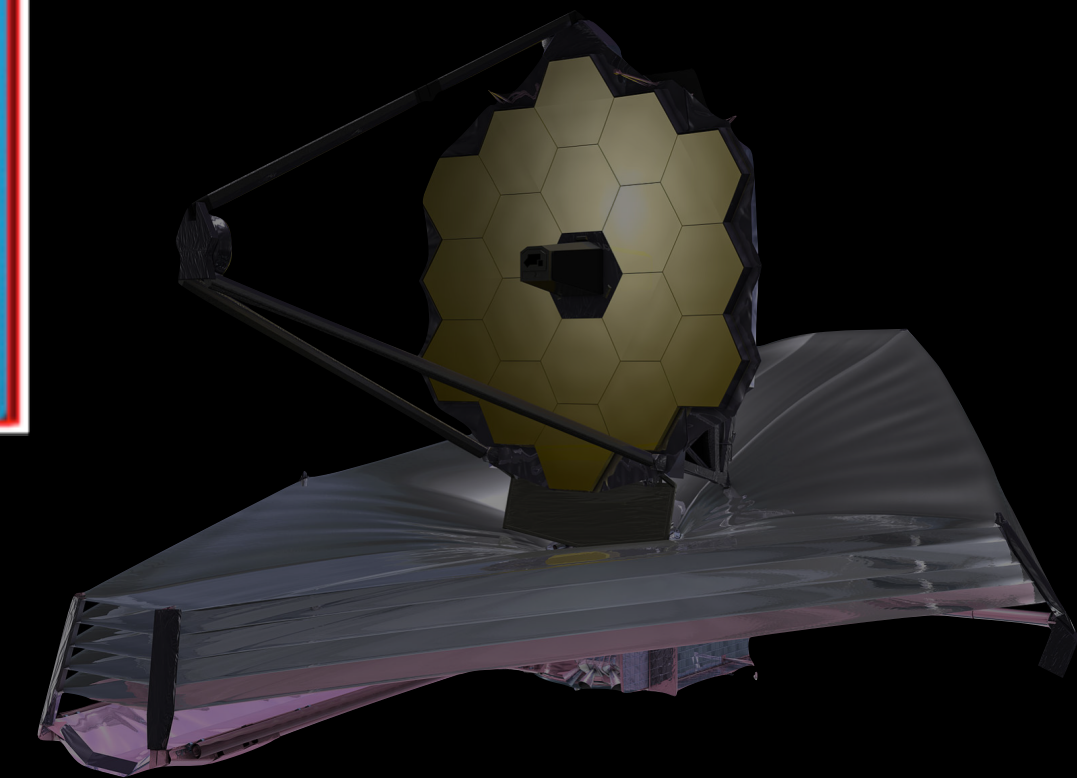
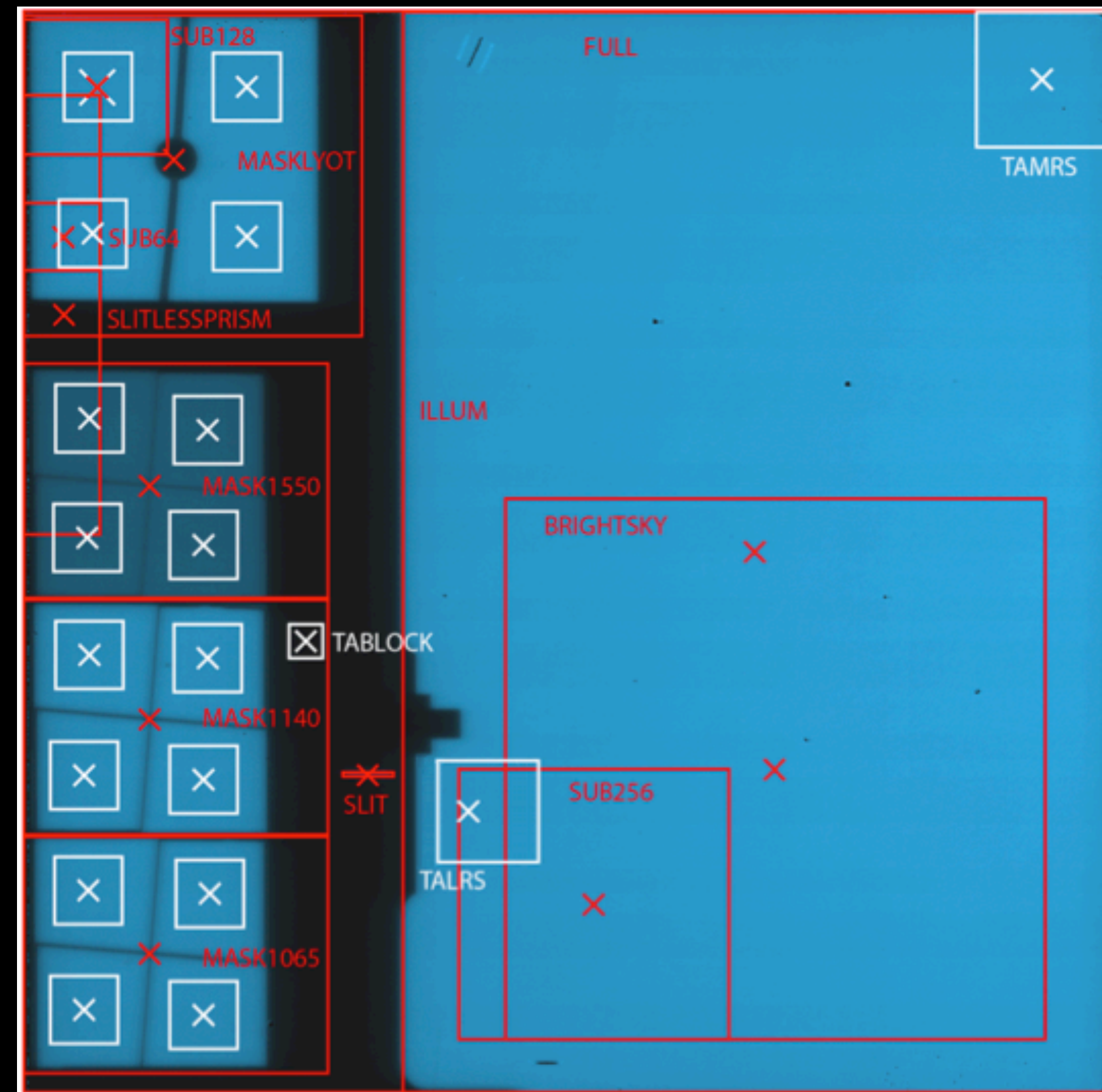
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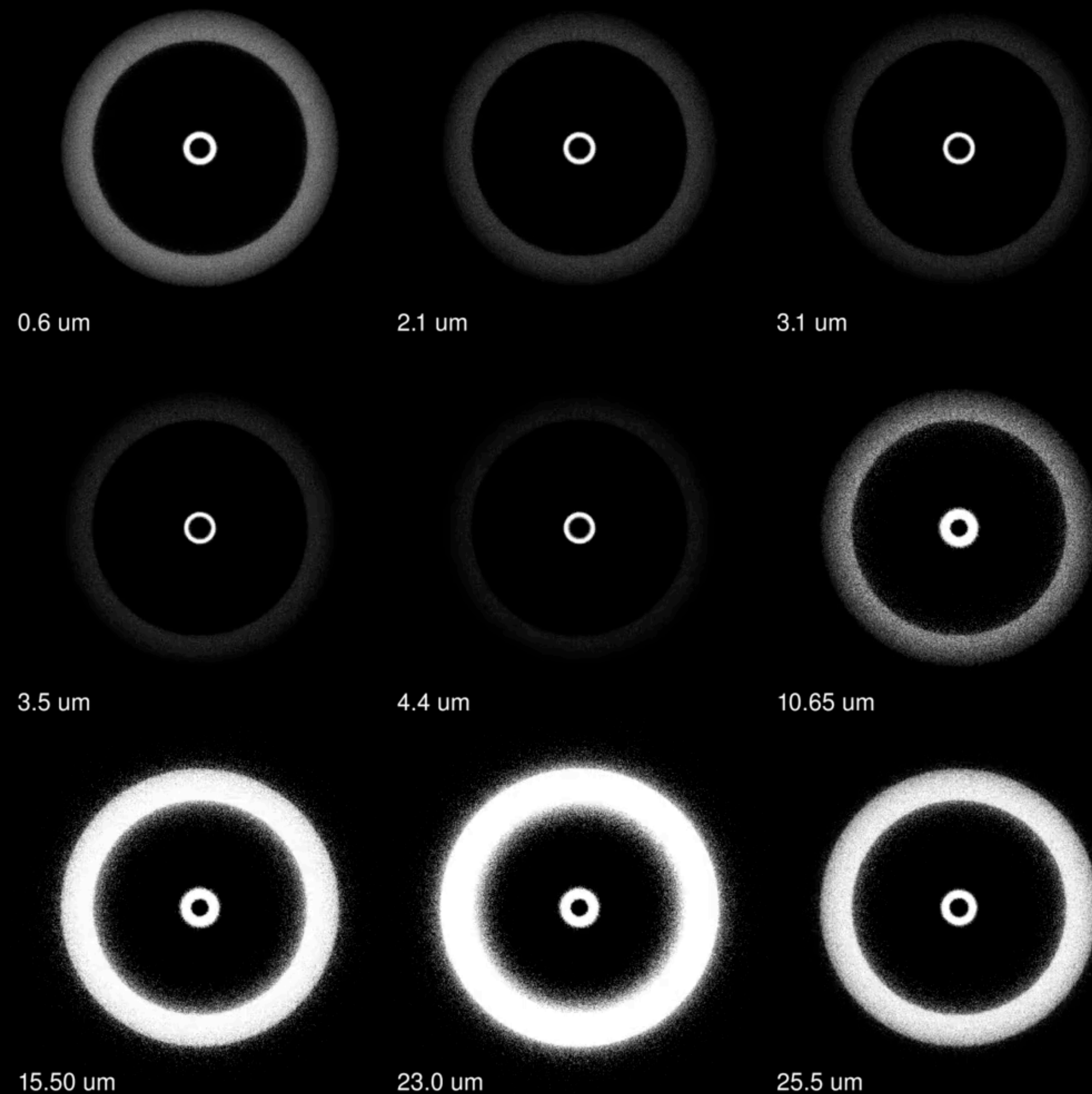
The MIRI GTO Archetypical Disks Program

Coronagraphic:
@ 15.5 μm (4QPM) and 23 μm (Lyot), using alternating T.A. quadrants. PSFs are dithered (9 point)

non-Coronagraphic
Imaging:
@ 25.5 μm using the BRIGHTSKY subarray and 4-point set dithering).

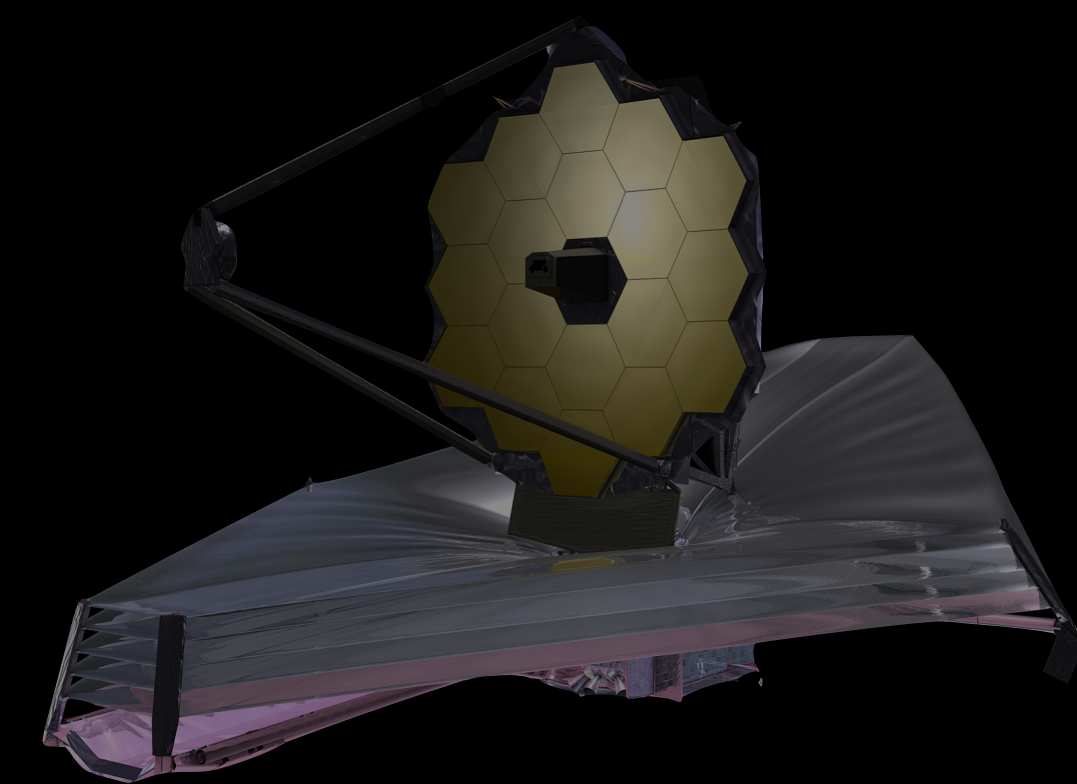


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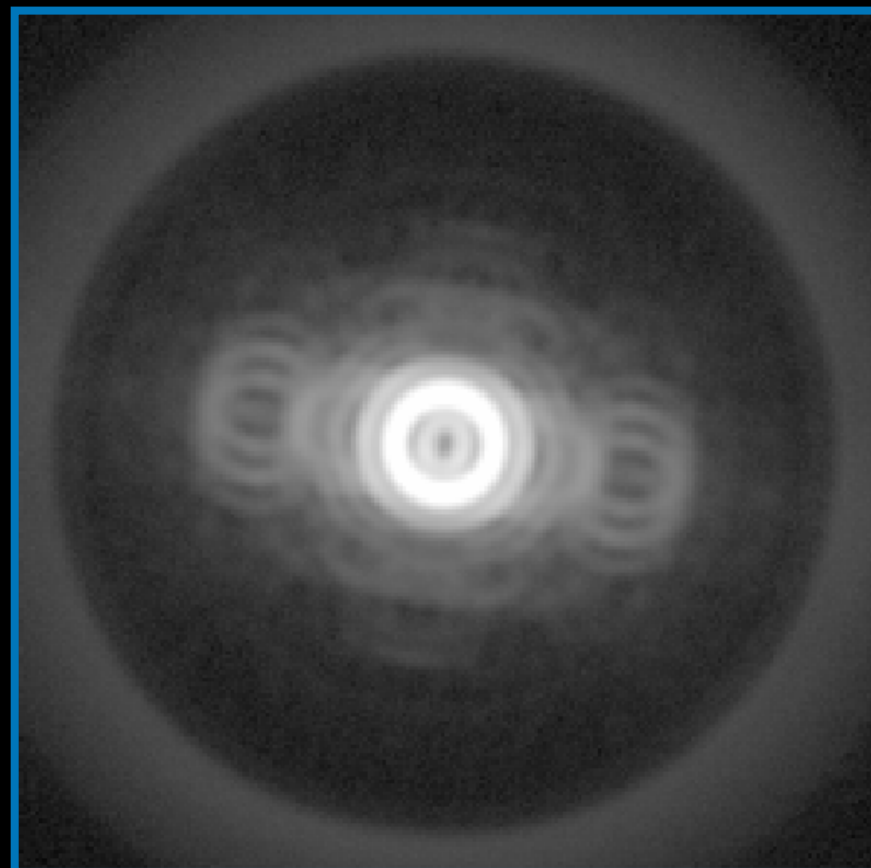
Vega

- A0V
- ~ 400 Myr
- 7.7 pc
- Extensive multi-wavelength dataset
- Spatially resolved with Spitzer
- Large solar system analog belts
- No resolved scattered light data

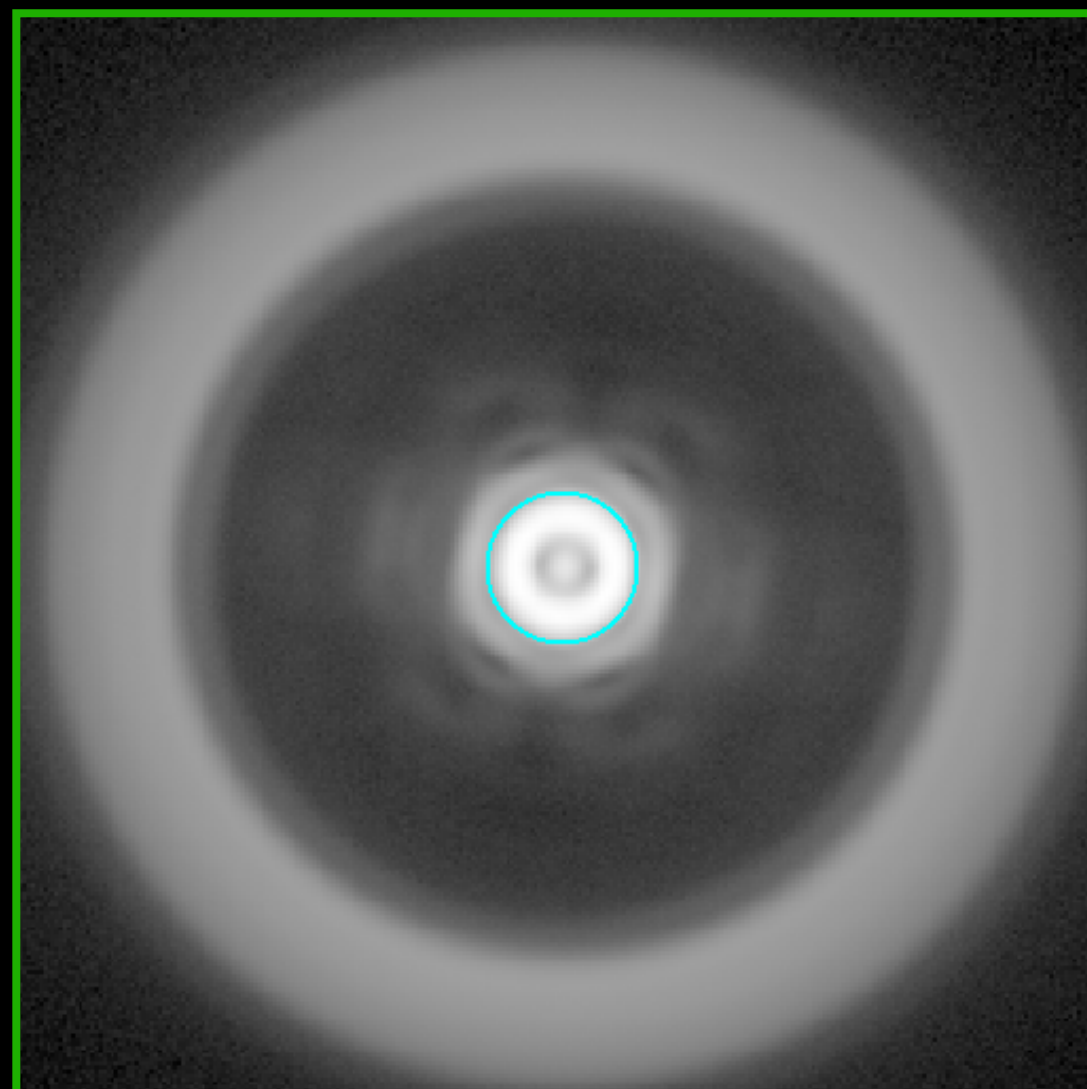


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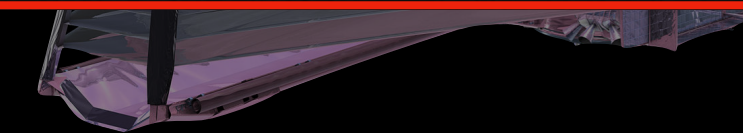
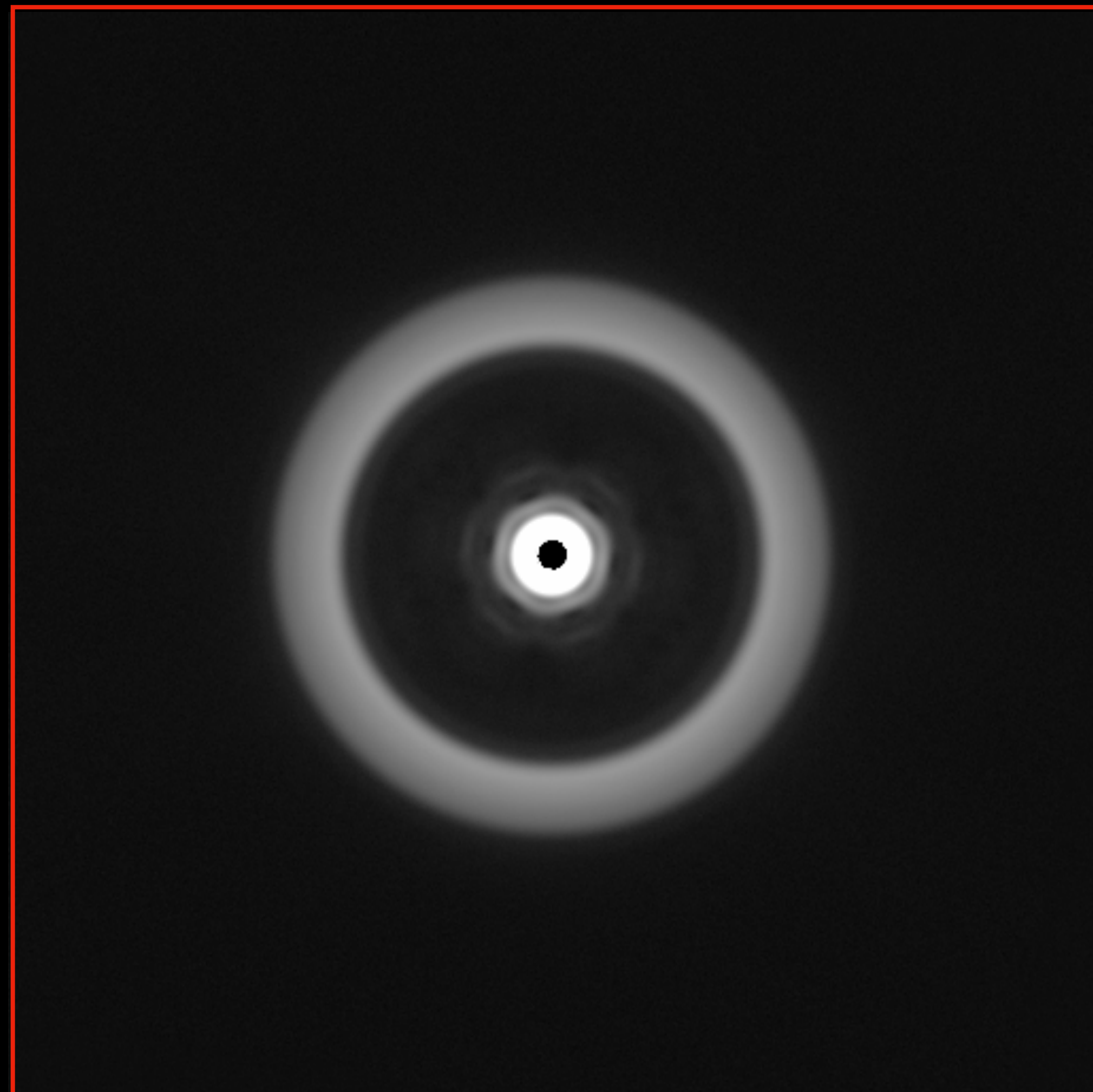
15.5 μm



23.0 μm



25.5 μm

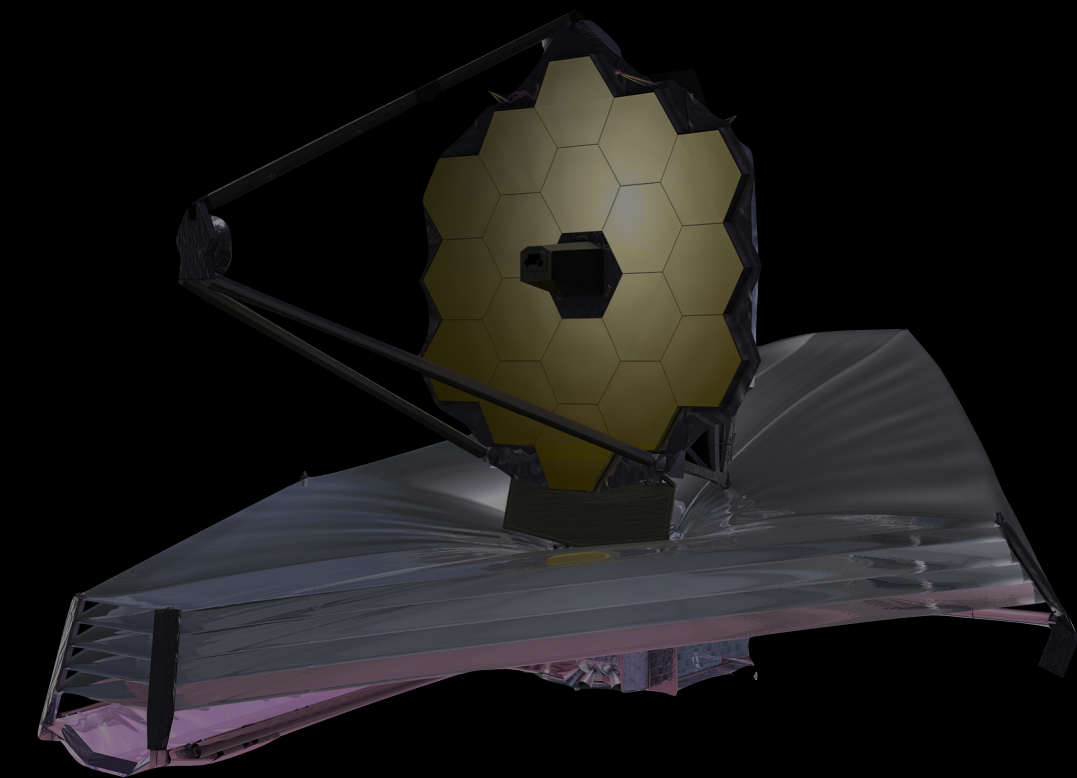


The MIRI GTO Archetypical Disks Program

Fomalhaut

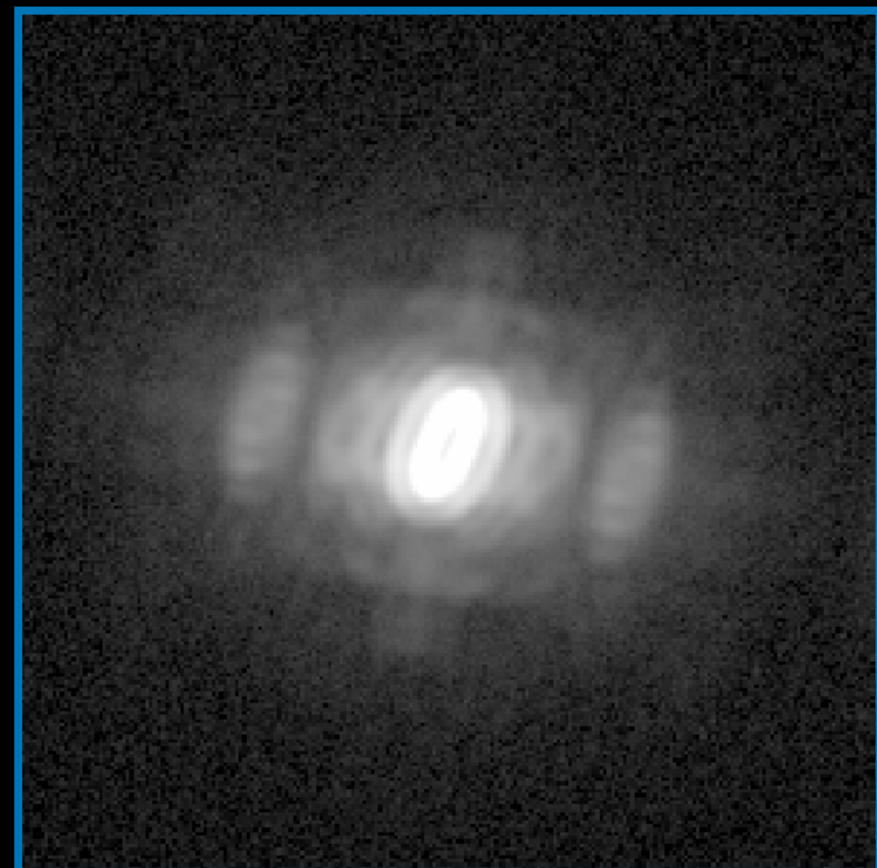


- A3V
- ~ 440 Myr
- 7.7 pc
- Outer Kuiper belt resolved at multiple wavelengths
- Inner asteroid belt inferred from thermal flux
- Recently approved HST program to spatially resolve its Asteroid belt analog (PI Gáspár)
- Possible planet detection (Kalas 2008)

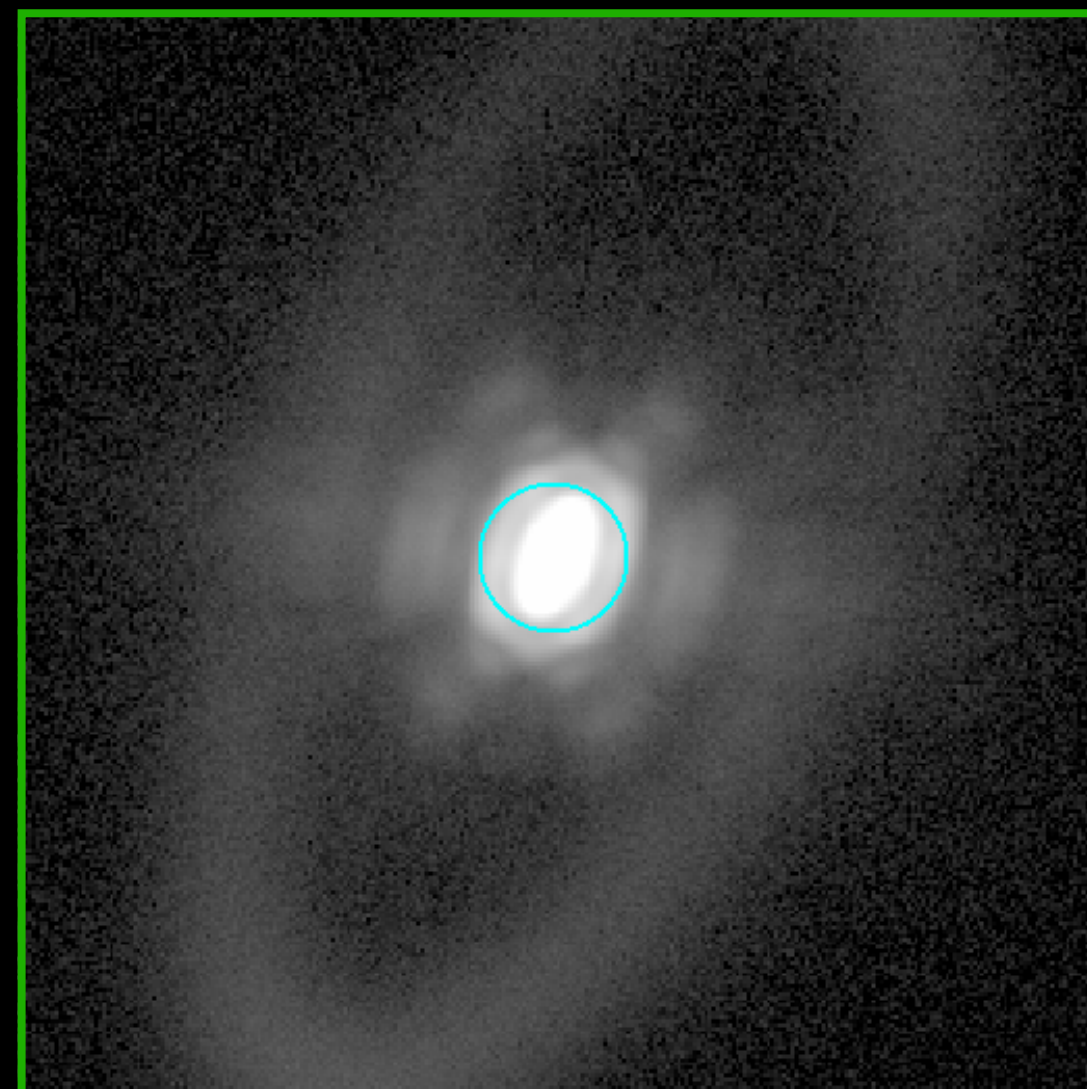


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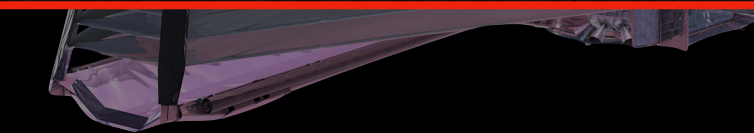
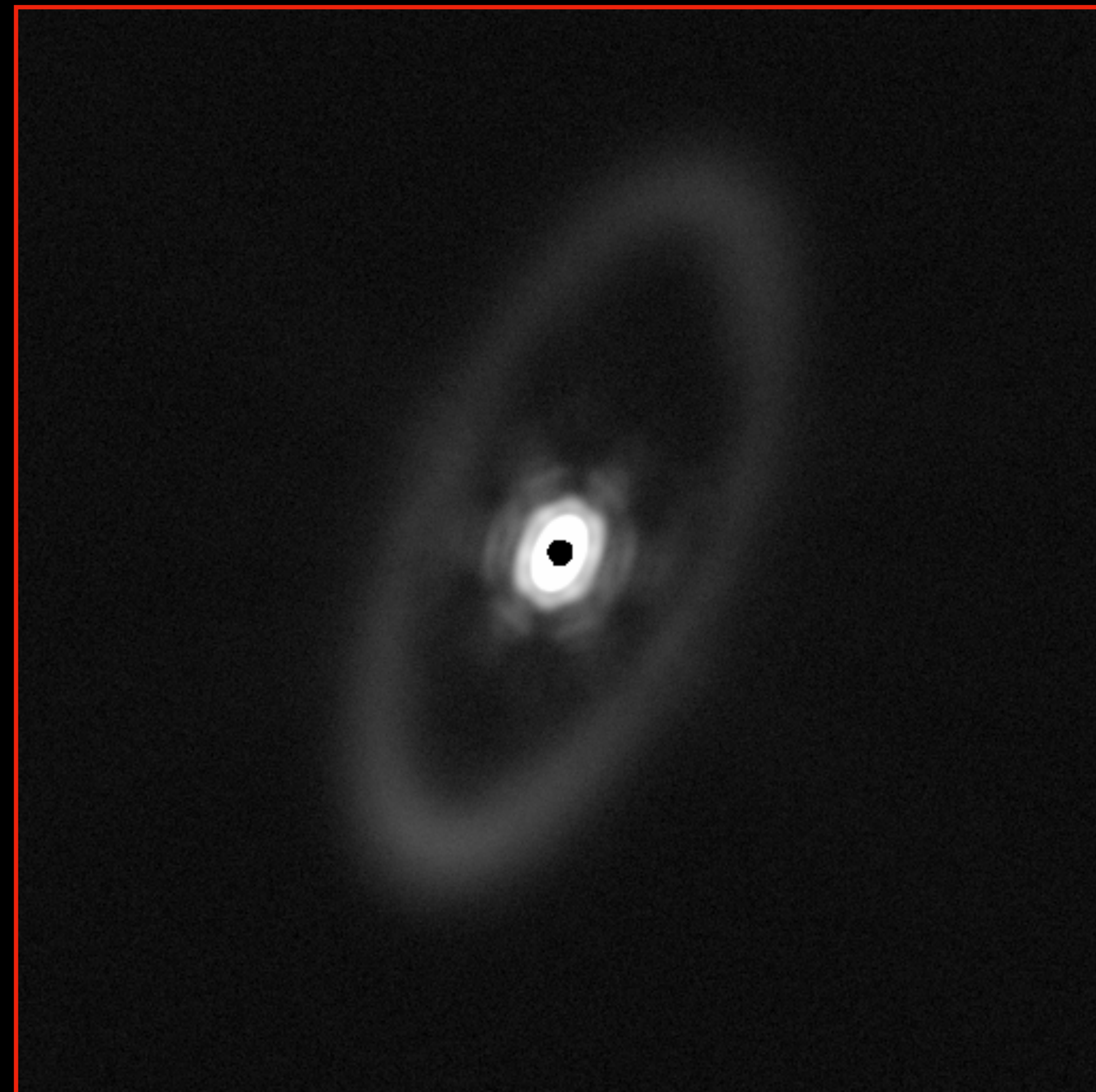
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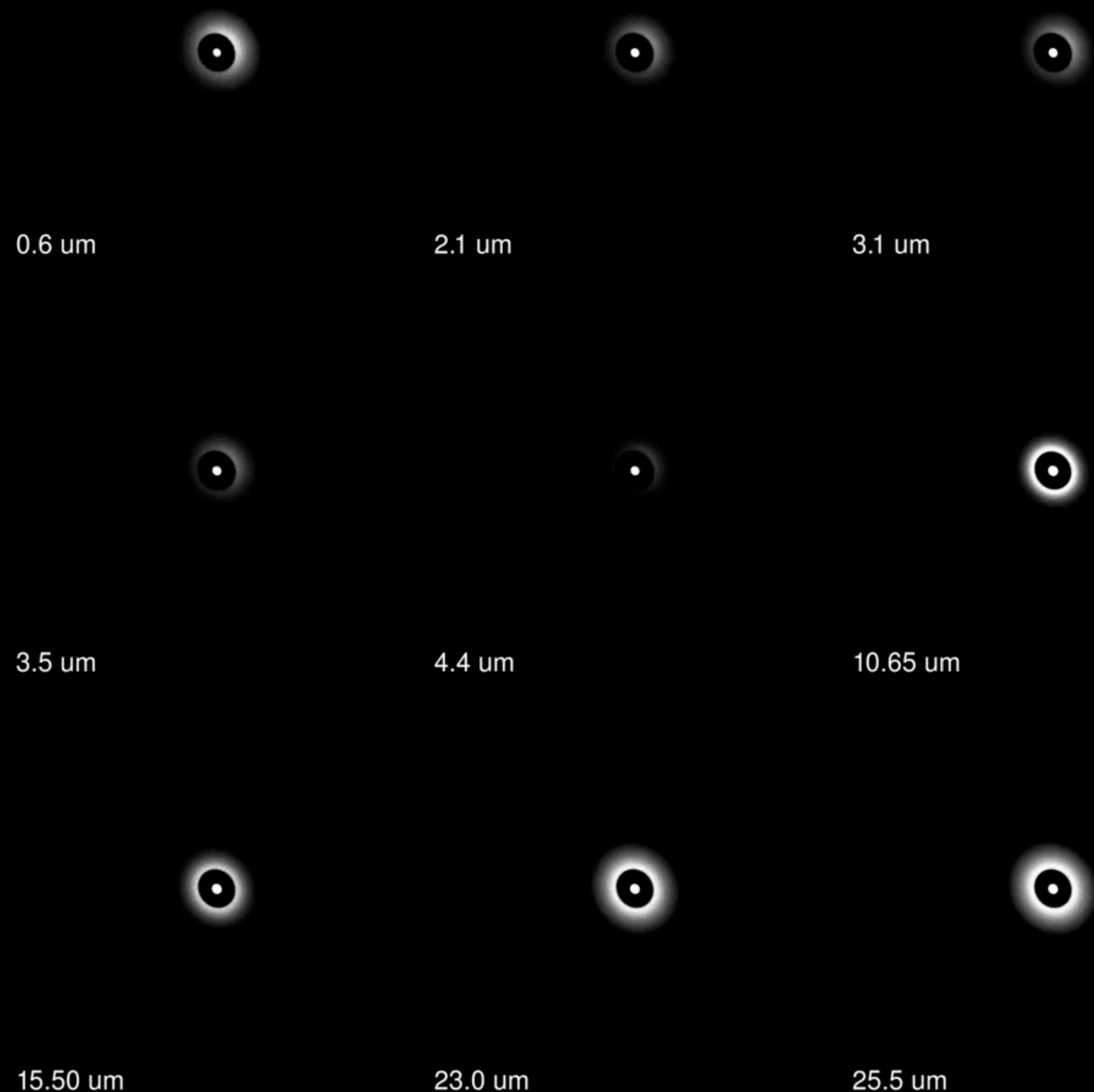


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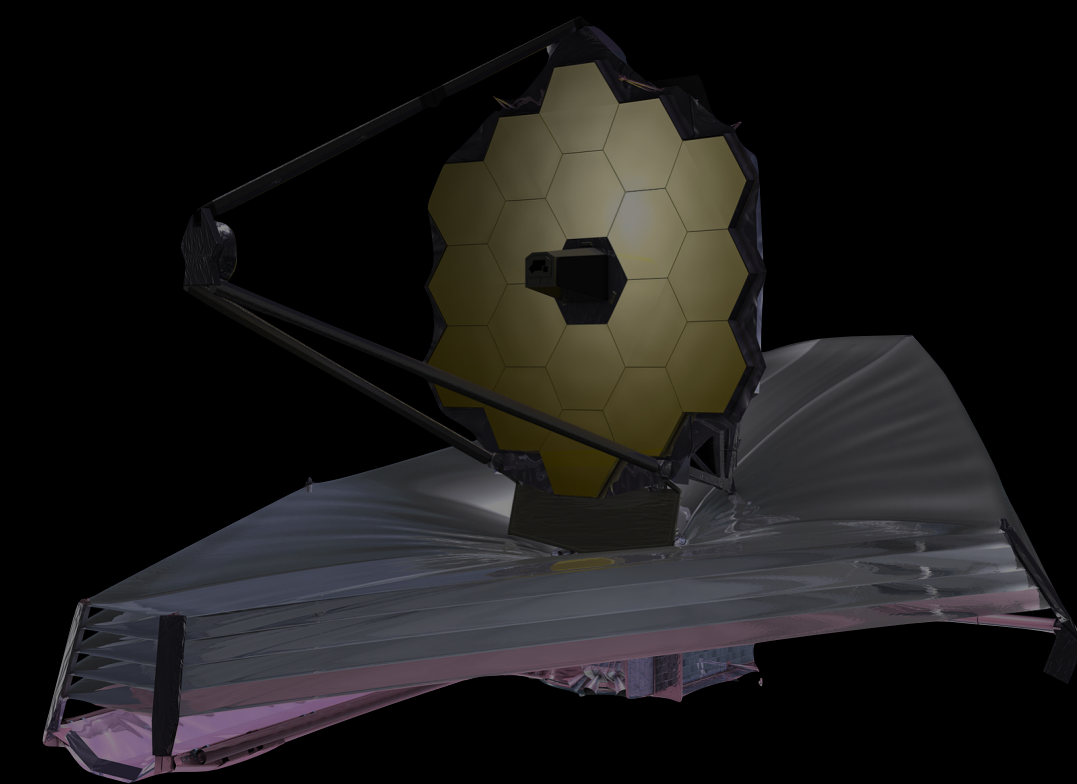


The MIRI GTO Archetypical Disks Program

epsilon Eridani

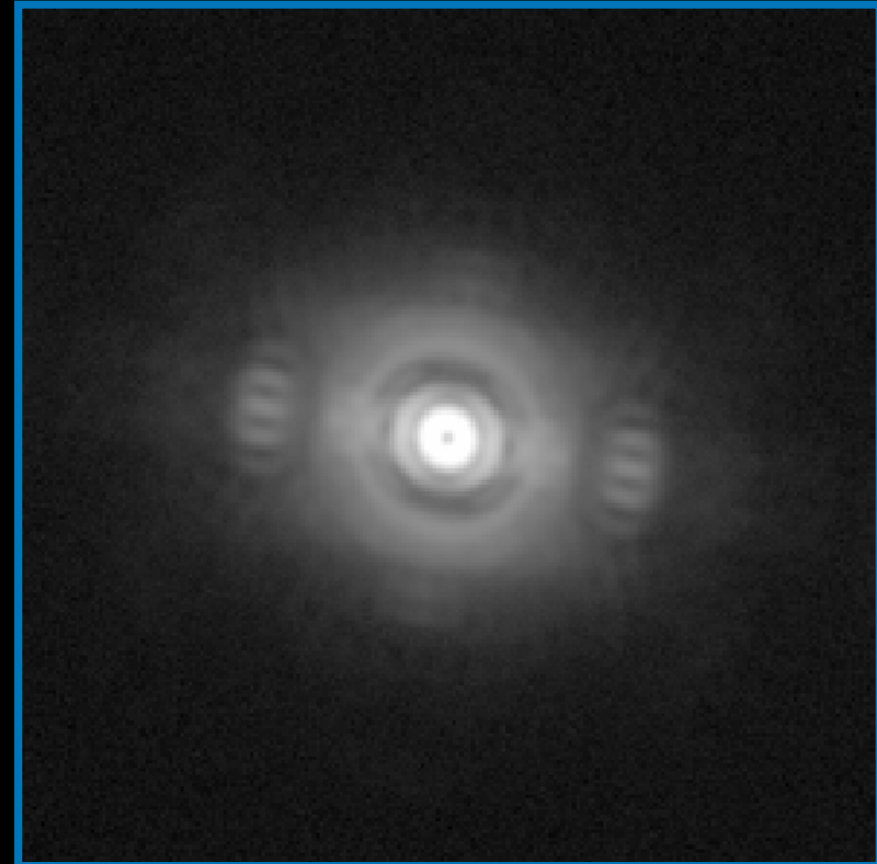


- K2V
- 400-800 Myr
- 3.2 pc
- True solar system analog with likely three belts
- Recently resolved with SOPHIA
- We have a recently approved HST program to resolve its belts in scattered light (PI Gáspár)
- Possible planet detection of a Jupiter analog (Hatzes 2008, Benedict 2006, Mawet 2019).

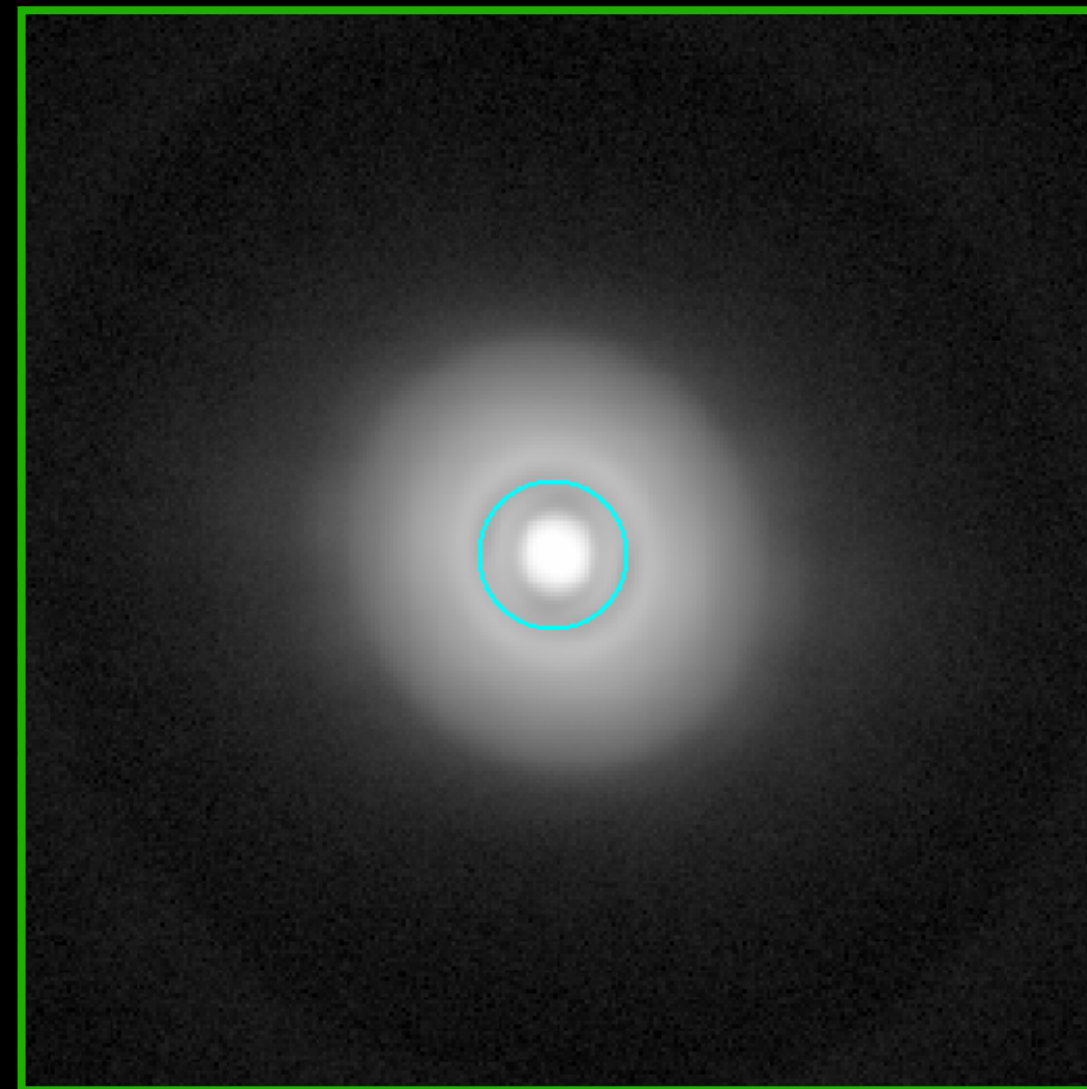


The MIRI GTO Archetypical Disks Program

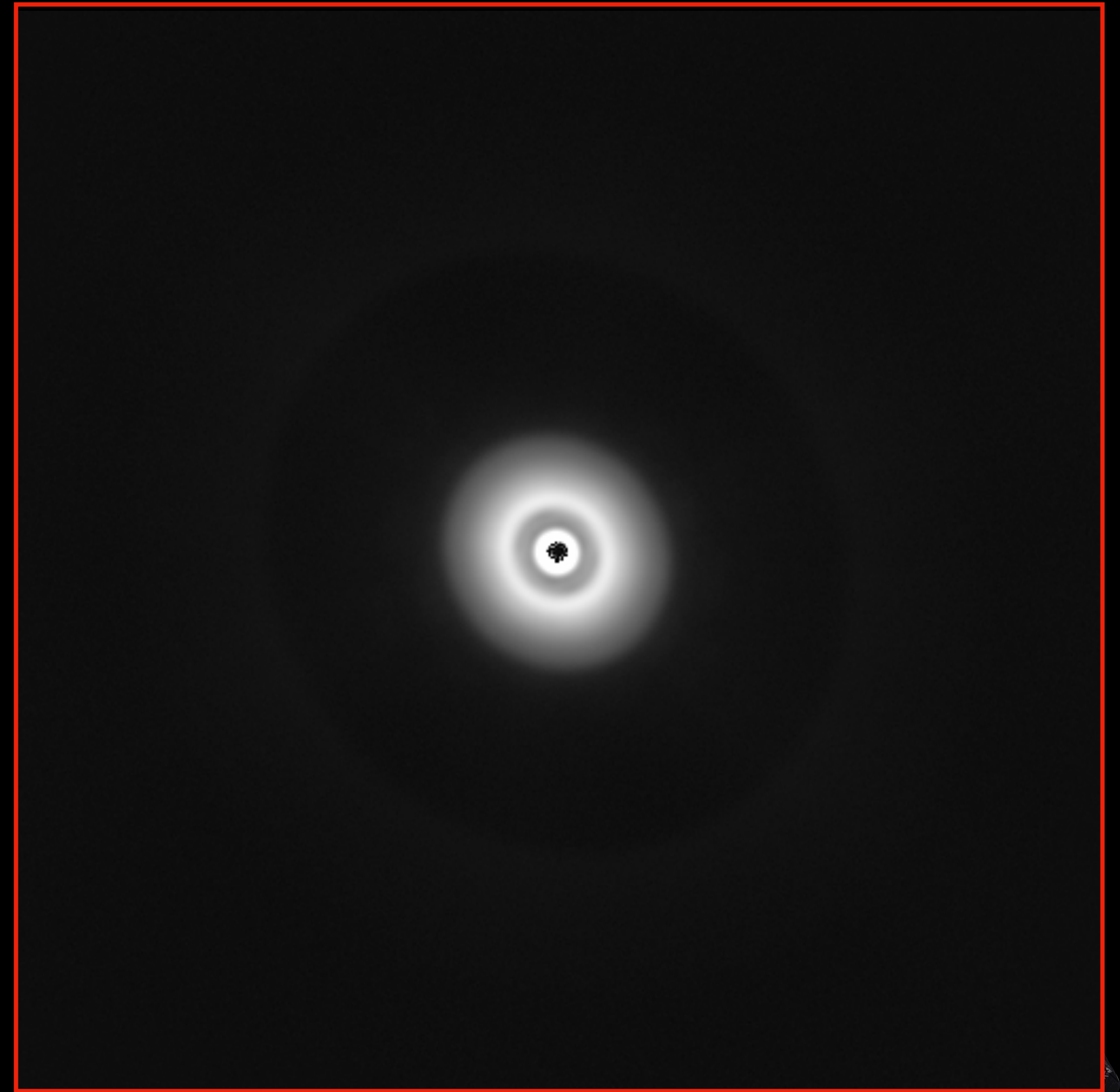
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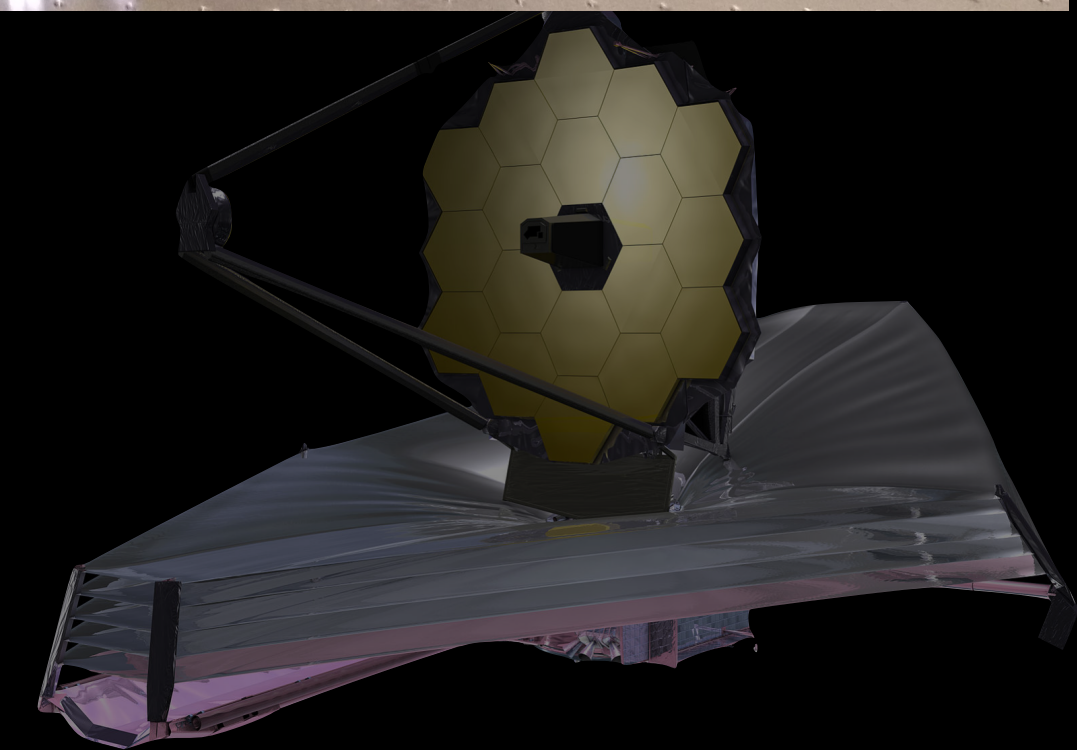
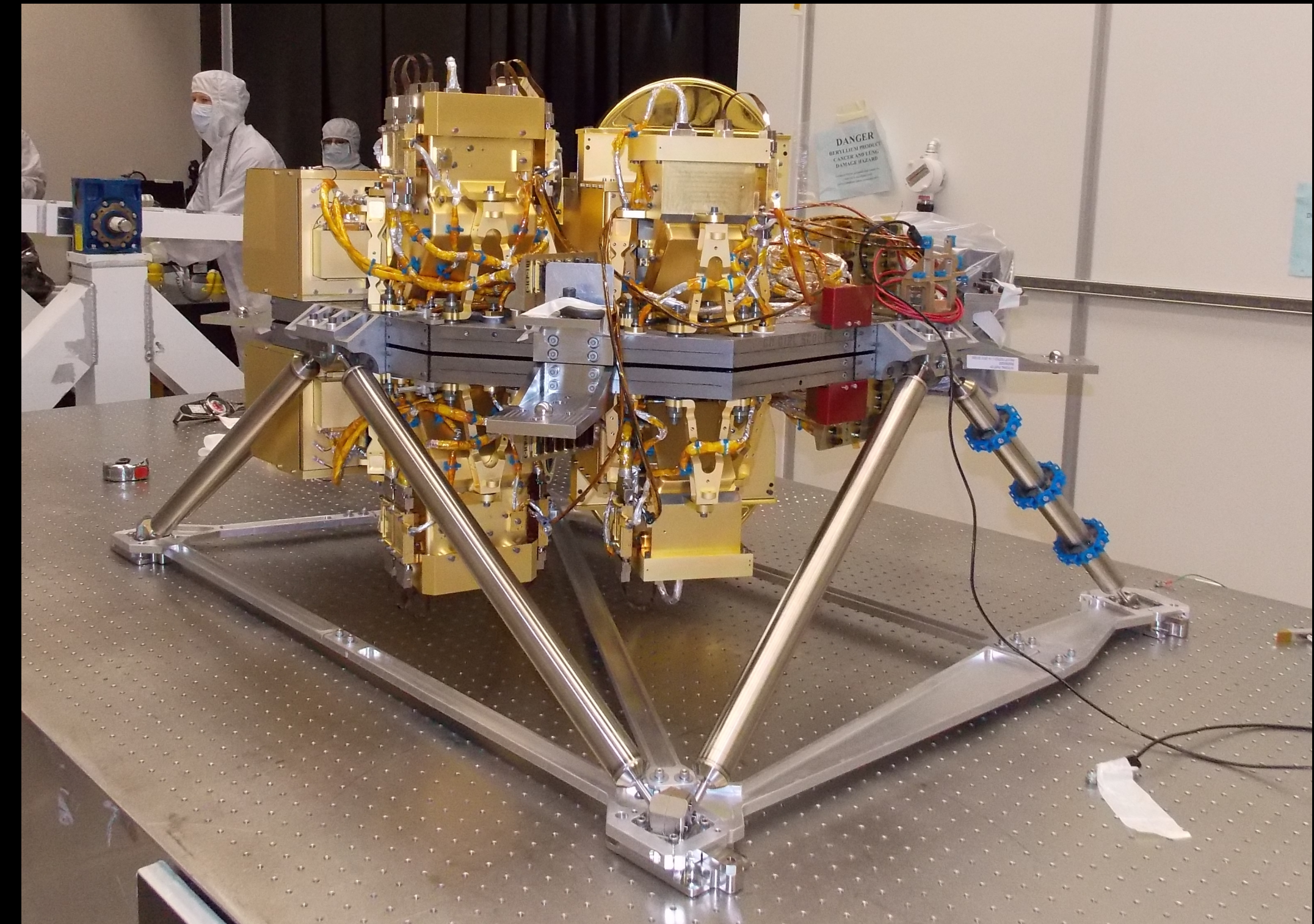
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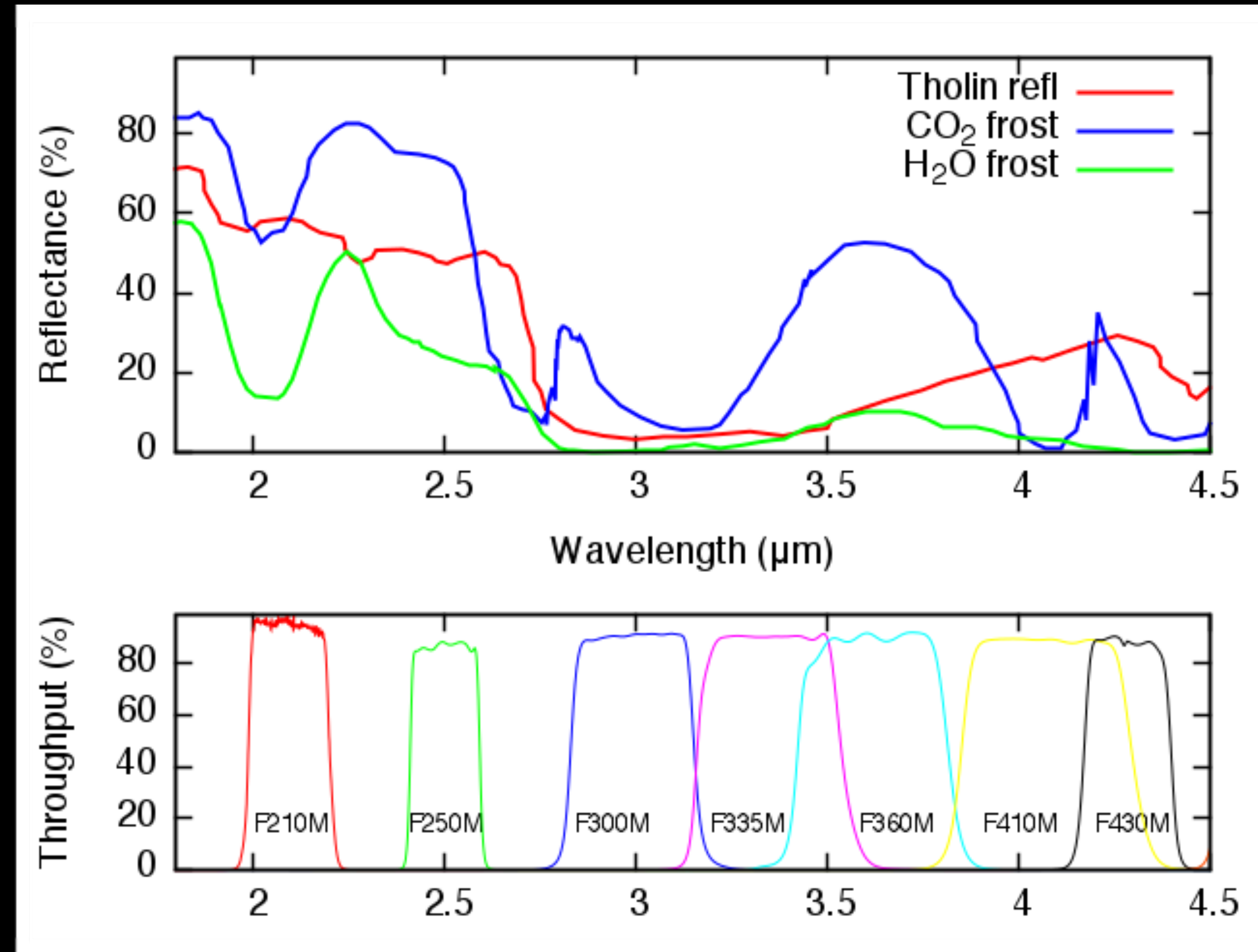
Program Goals

Goals of the program are to resolve the full belt systems of the brightest scattered light disks in the IR and answer questions:

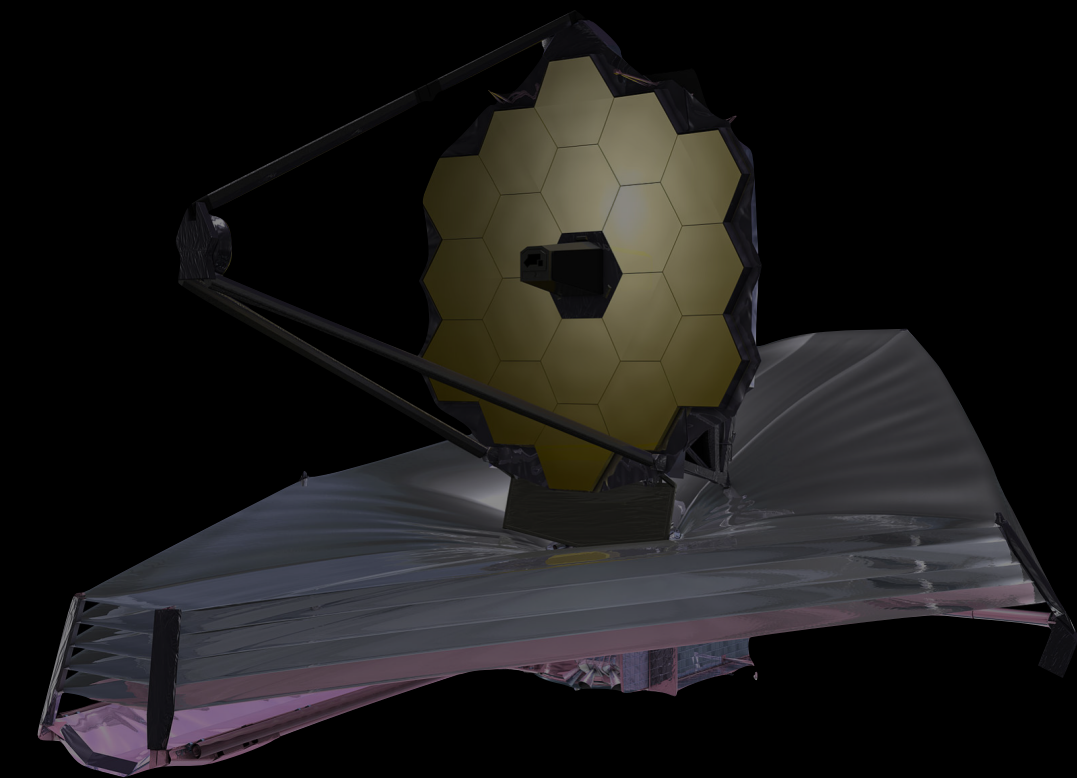
- Disk compositions represent those of parent planetesimals - are they universal? what are they? do they resemble KBOs?
- Grain sizes reveal intensity of collisional activity, locations probe non-gravitational forces. How do they relate to stellar type and other disk characteristics?
- What are the scattering phase functions (SPF) of the grains in the systems?
- Are there indications of planetary interactions with the disks in these systems?
- Can we possibly image any planets in these systems?



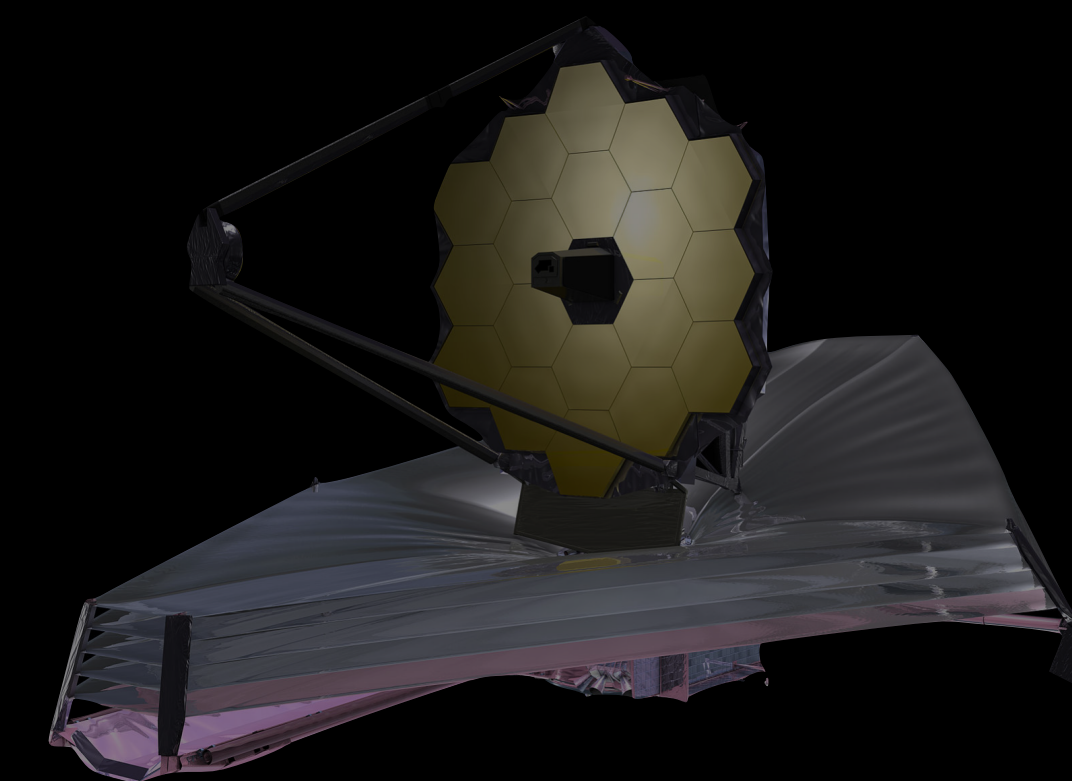
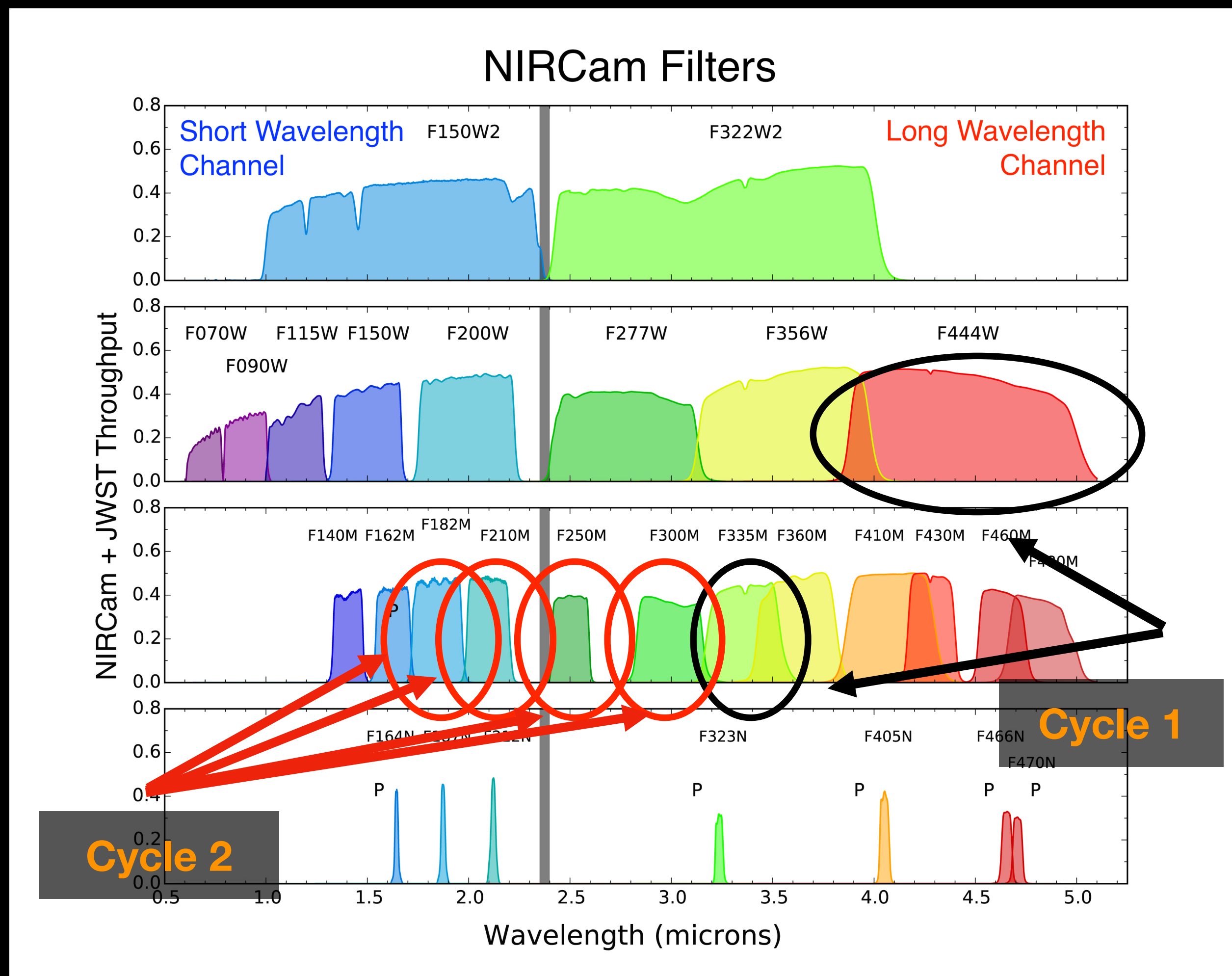
The NIRCcam GTO Scattered Light Disks Program



- We expect to recover the composition in our target systems using the following filters: F182M, F210M, F250M, F300M, F360M, and F444W.

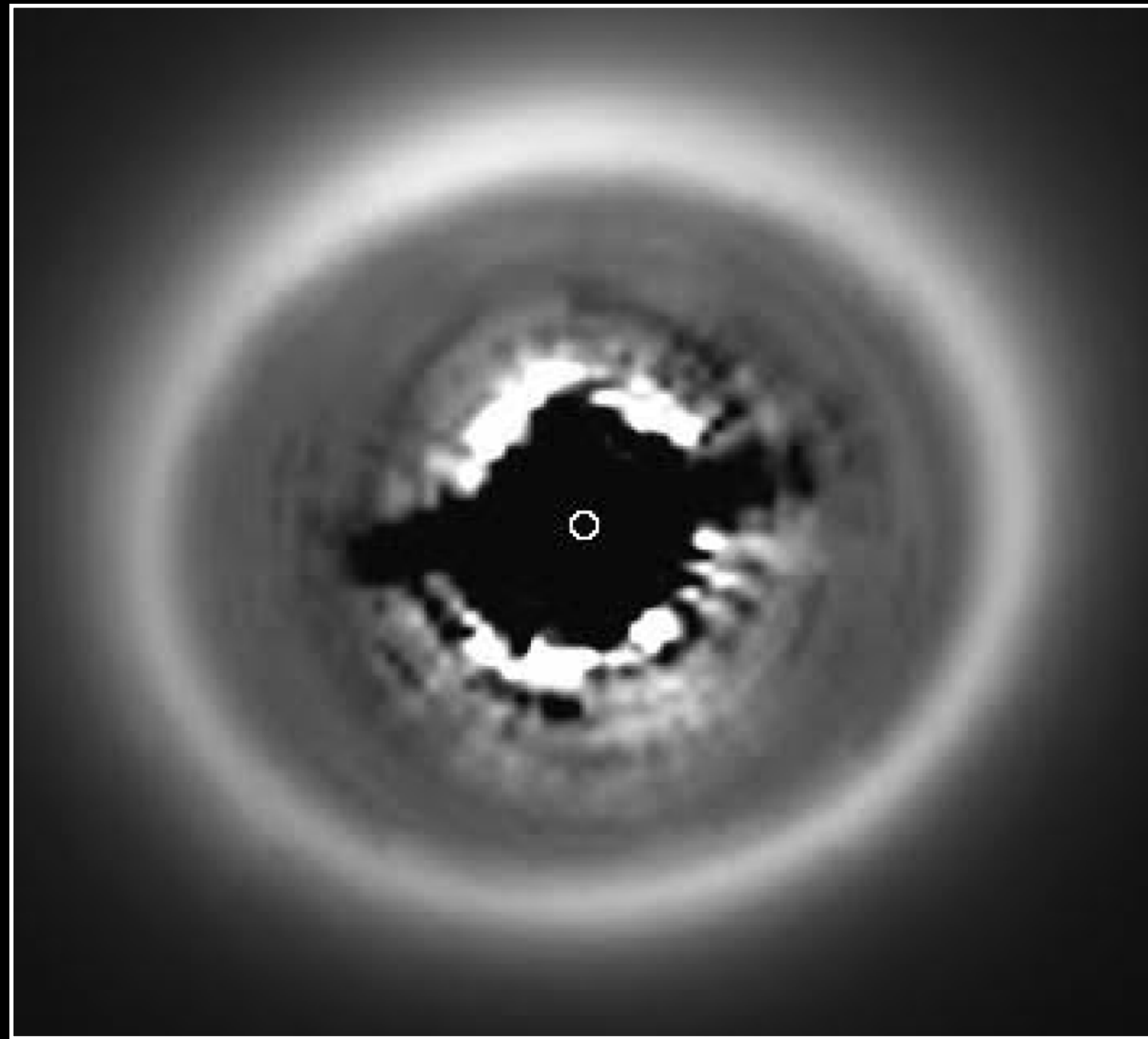


The NIRCcam GTO Scattered Light Disks Program



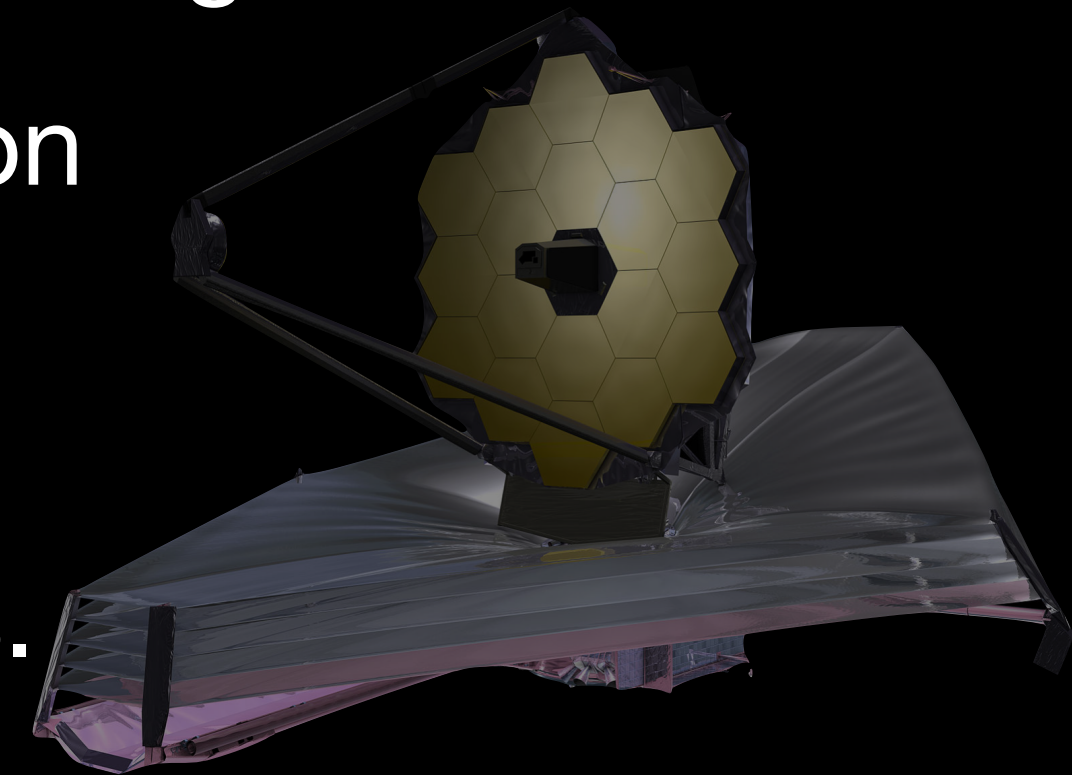
The NIRCams GTO Scattered Light Disks Program

HD 181327



Schneider et al. (2014)

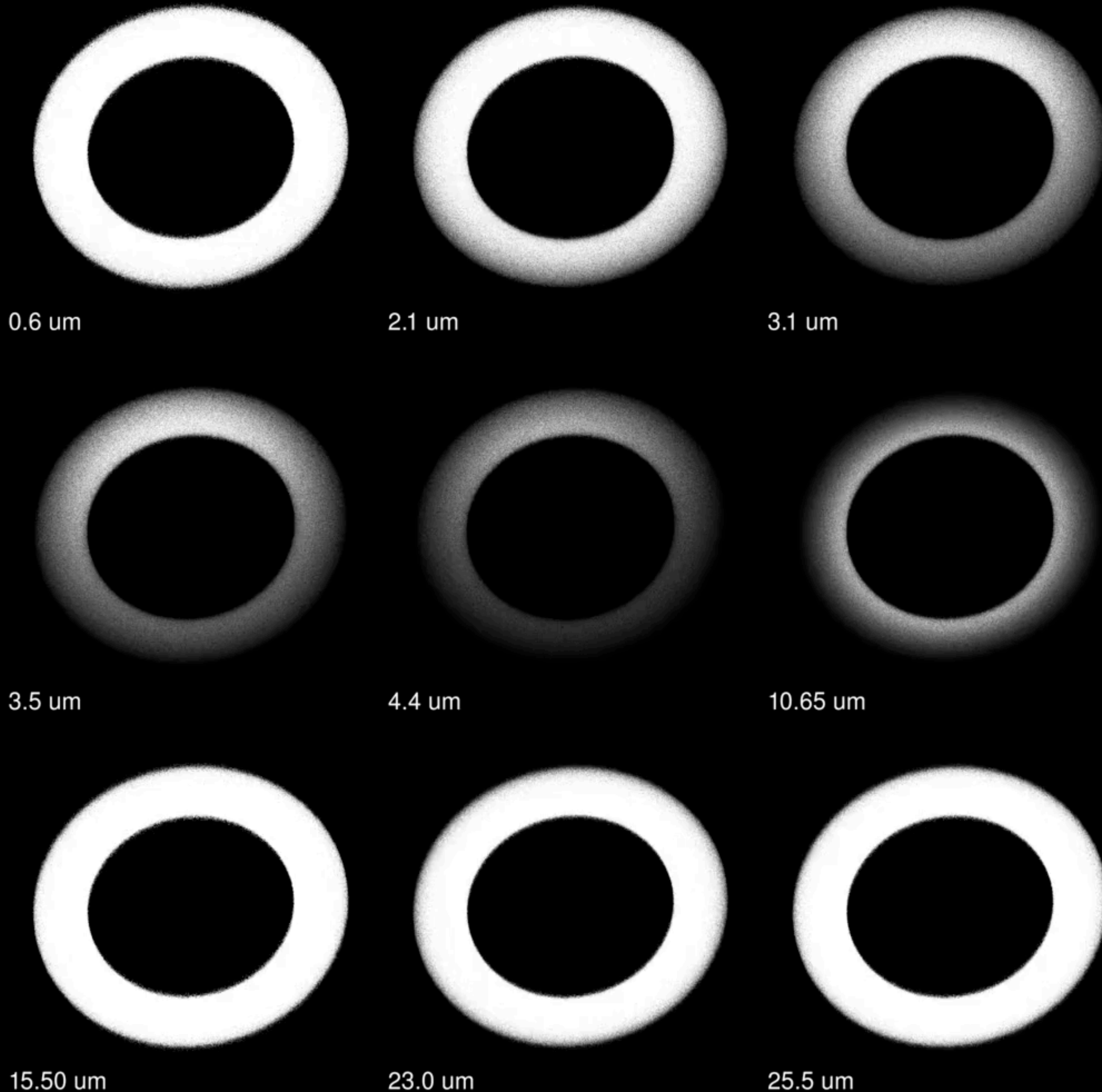
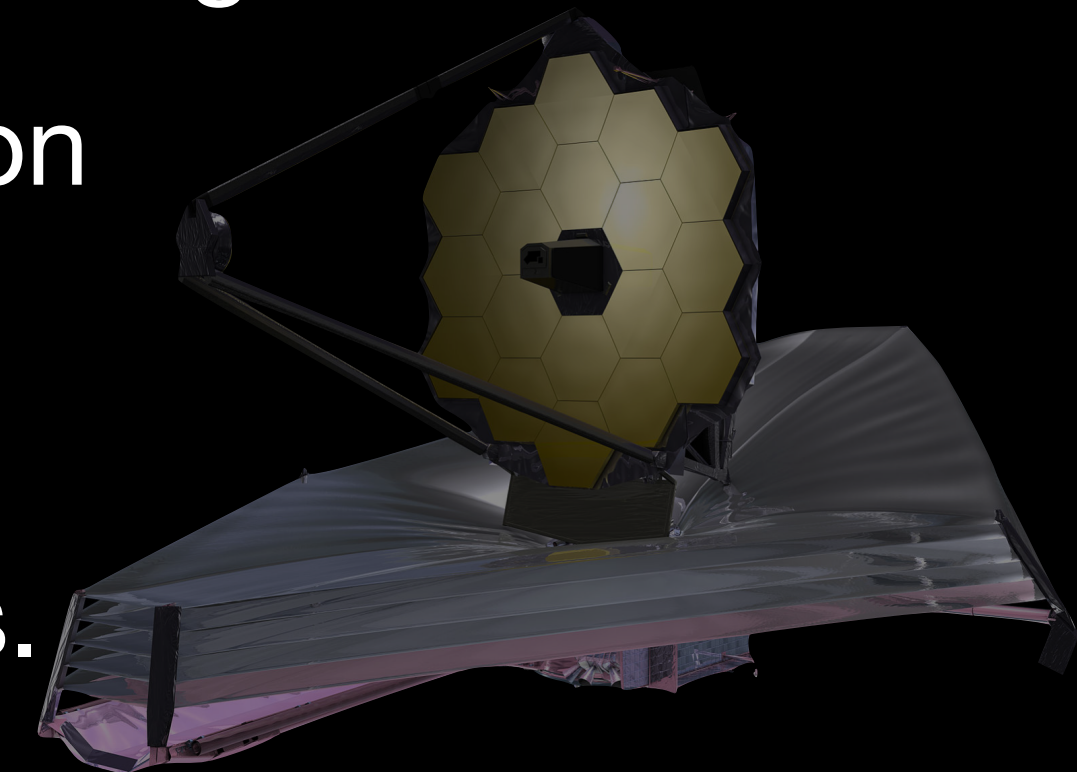
- Disk is nearly face-on, allowing dynamics to be studied.
- Well resolved with HST/STIS
- Stark et al. (2014) studied the SPF in the system. Highly forward scattering!
- Dust-size segregation studies
- Ideal system for composition studies.



The NIRCams GTO Scattered Light Disks Program

HD 181327

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The NIRCams GTO Scattered Light Disks Program

2.0 micron

HD 181327

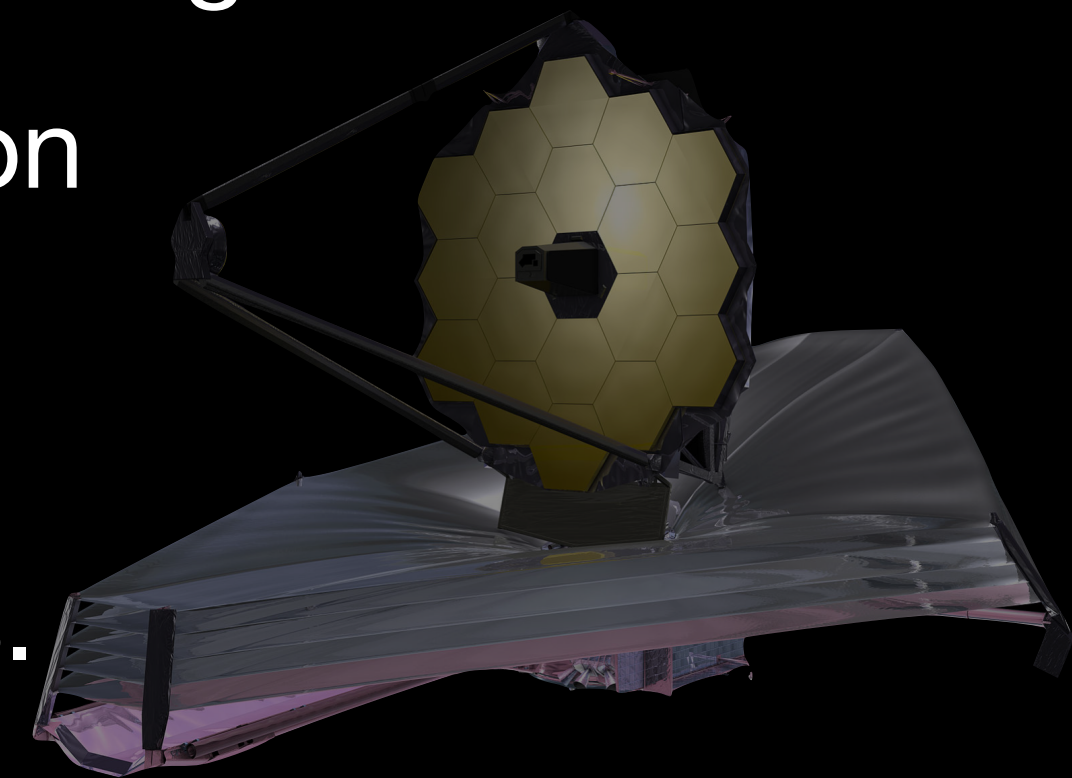
- Disk is nearly face-on, allowing dynamics to be studied.
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Silicate

Water

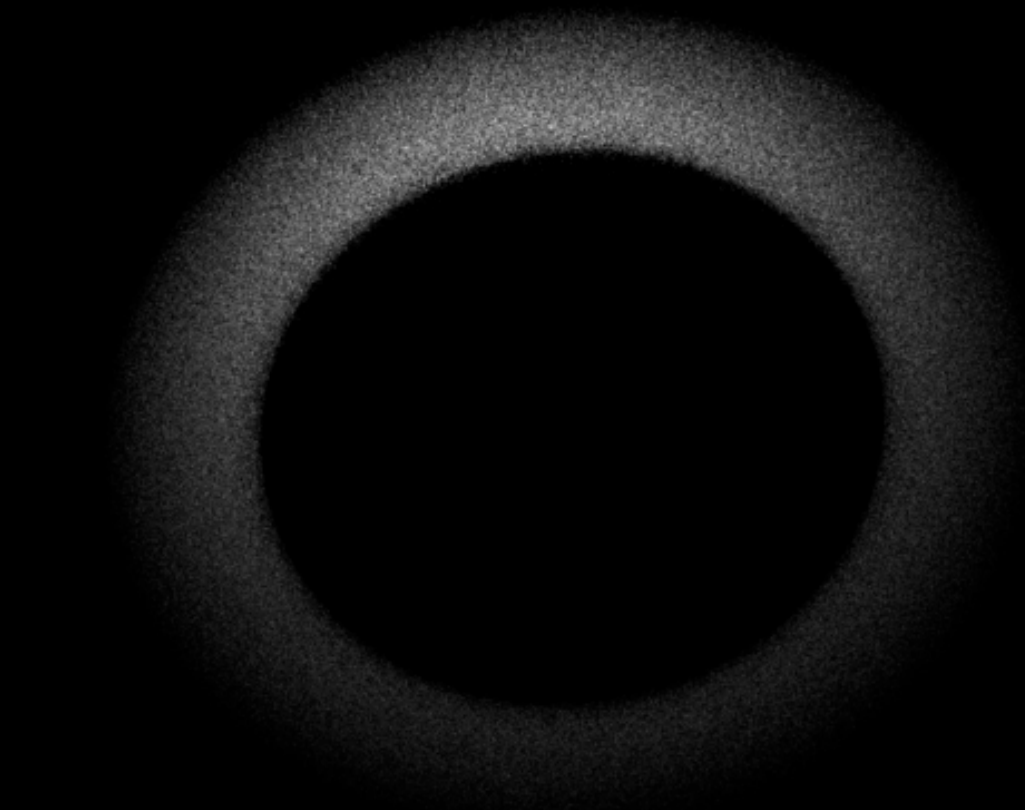
Olivine

Organics



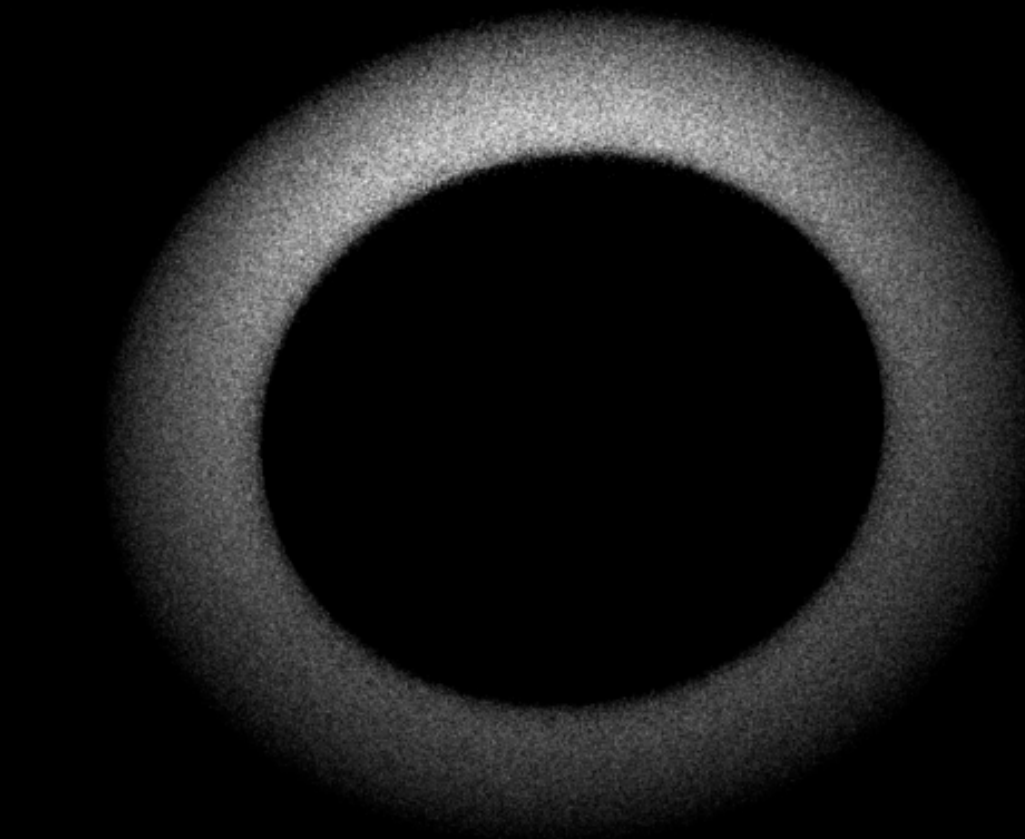
The NIRCams GTO Scattered Light Disks Program

2.9 micron

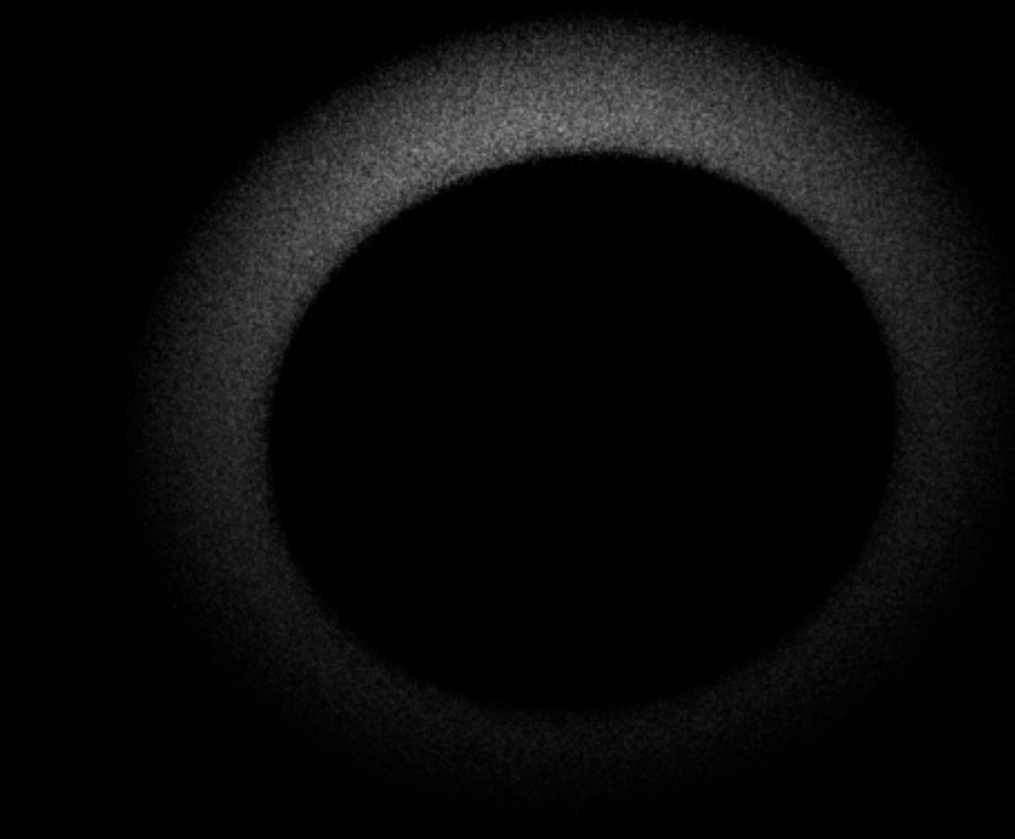


Silicate

Water



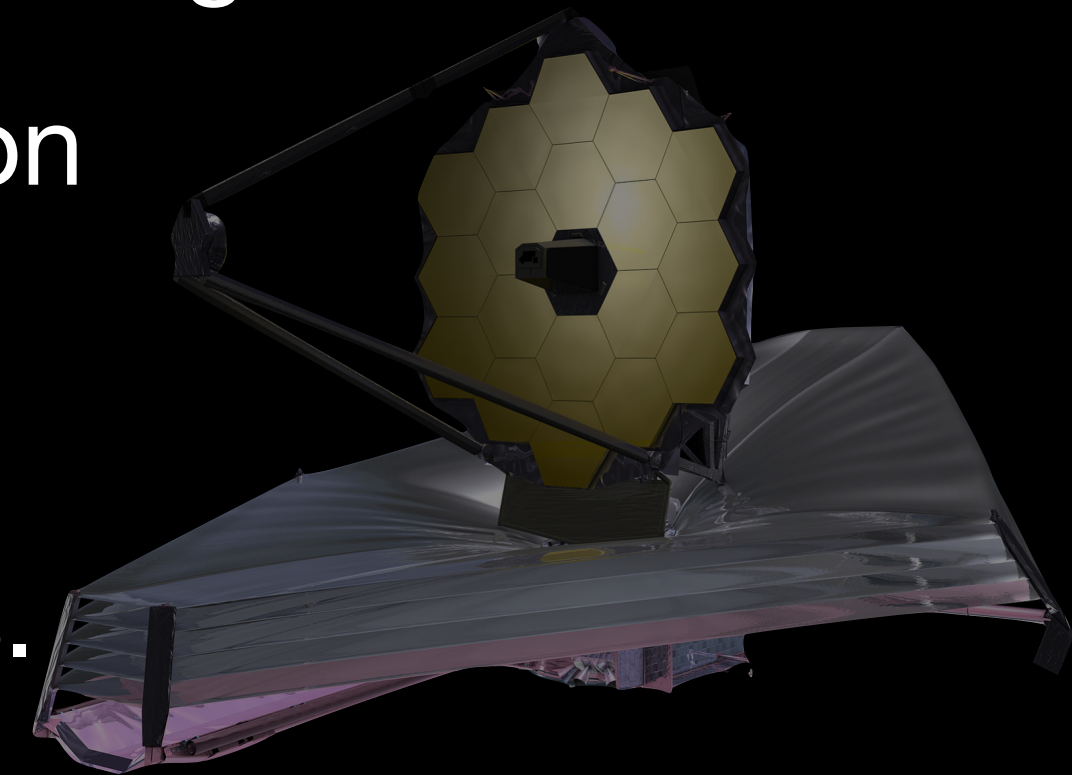
Olivine



Organics

HD 181327

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The NIRCams GTO Scattered Light Disks Program

3.5 micron

Silicate

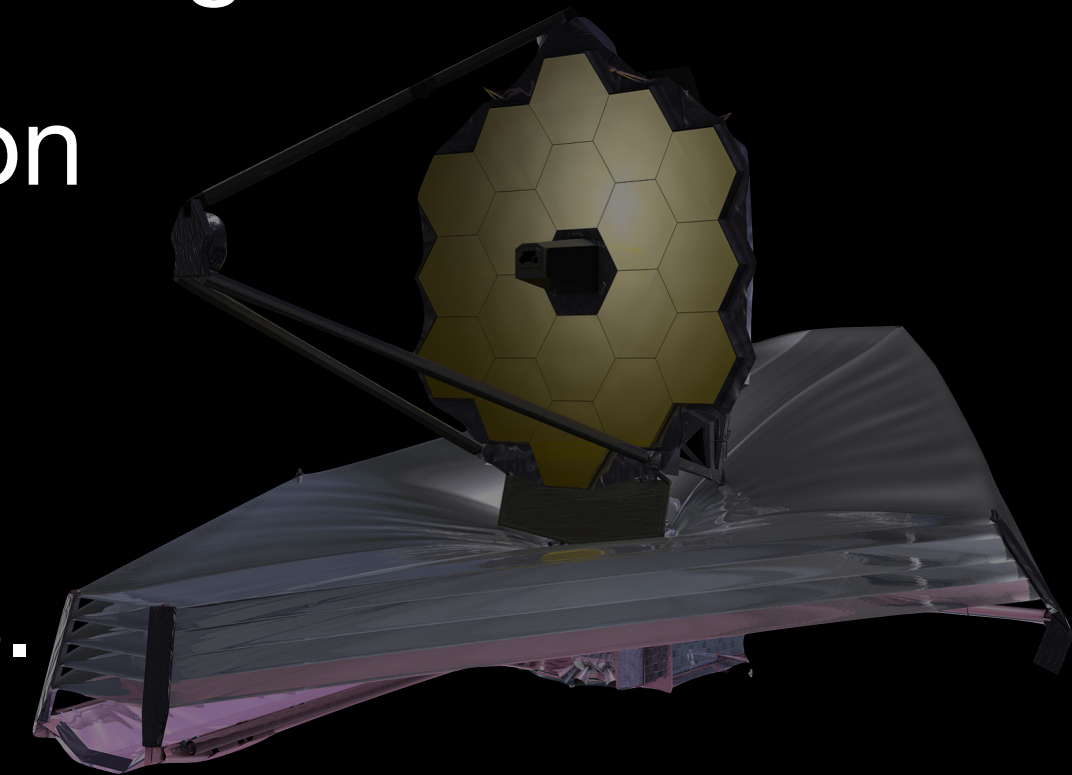
Water

Olivine

Organics

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The NIRCarn GTO Scattered Light Disks Program

4.2 micron

Silicate

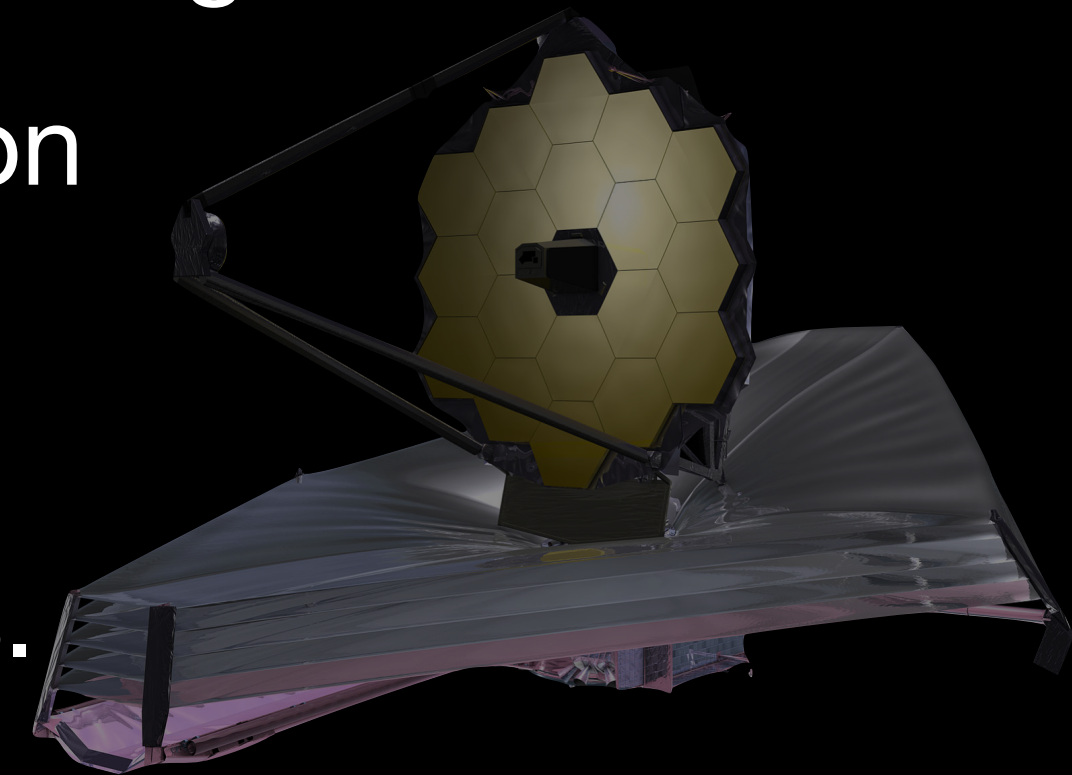
Water

Olivine

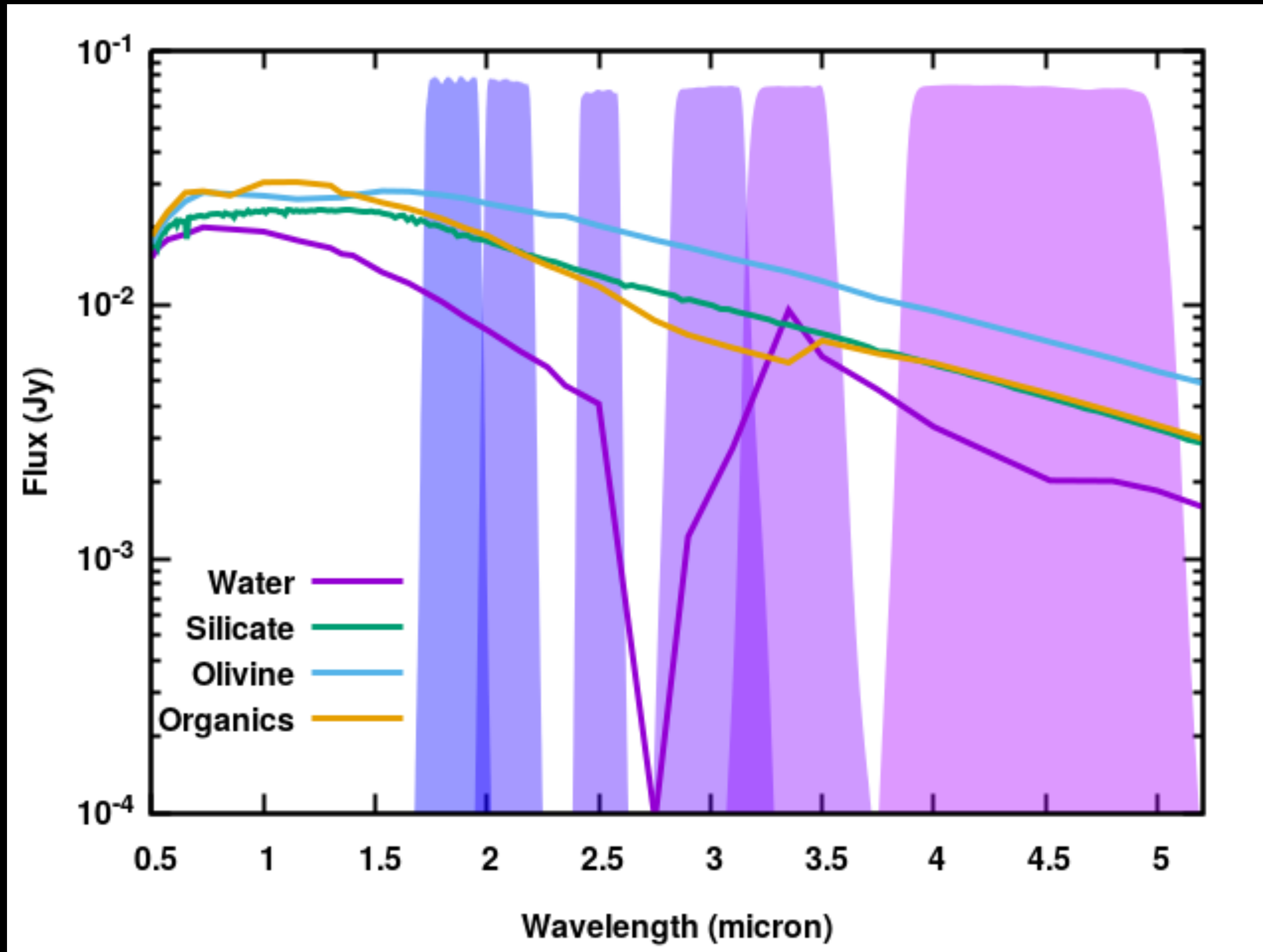
Organics

HD 181327

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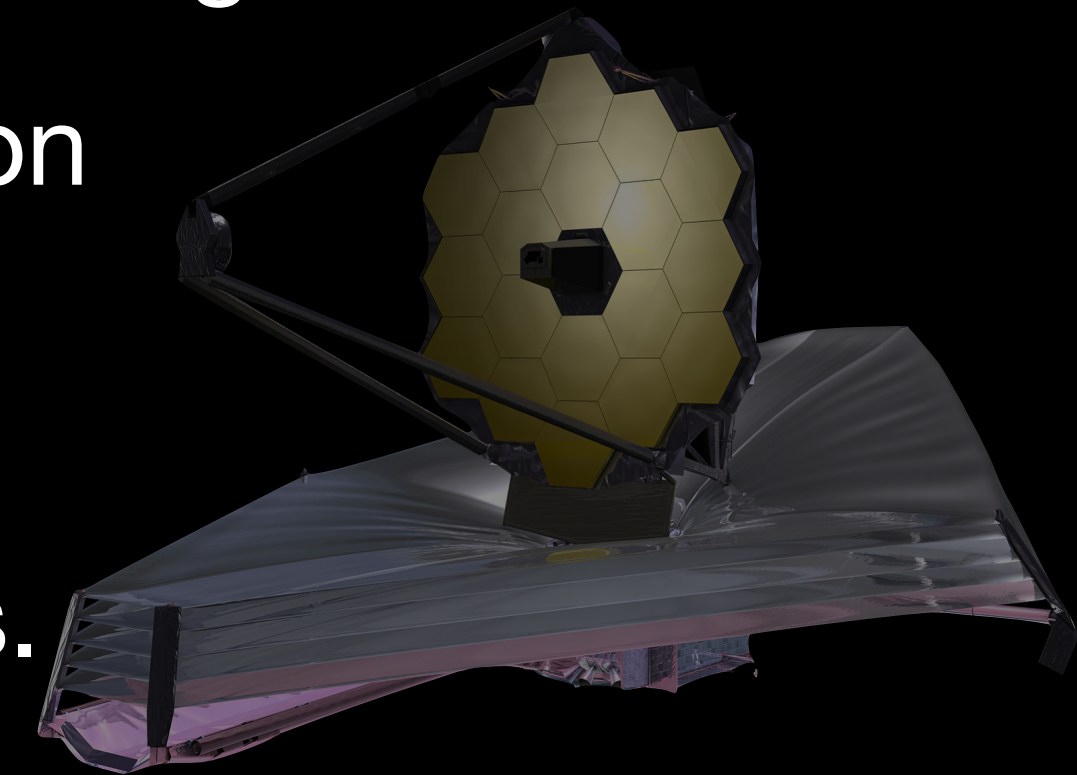


The NIRCам GTO Scattered Light Disks Program



HD 181327

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The NIRCams GTO Scattered Light Disks Program

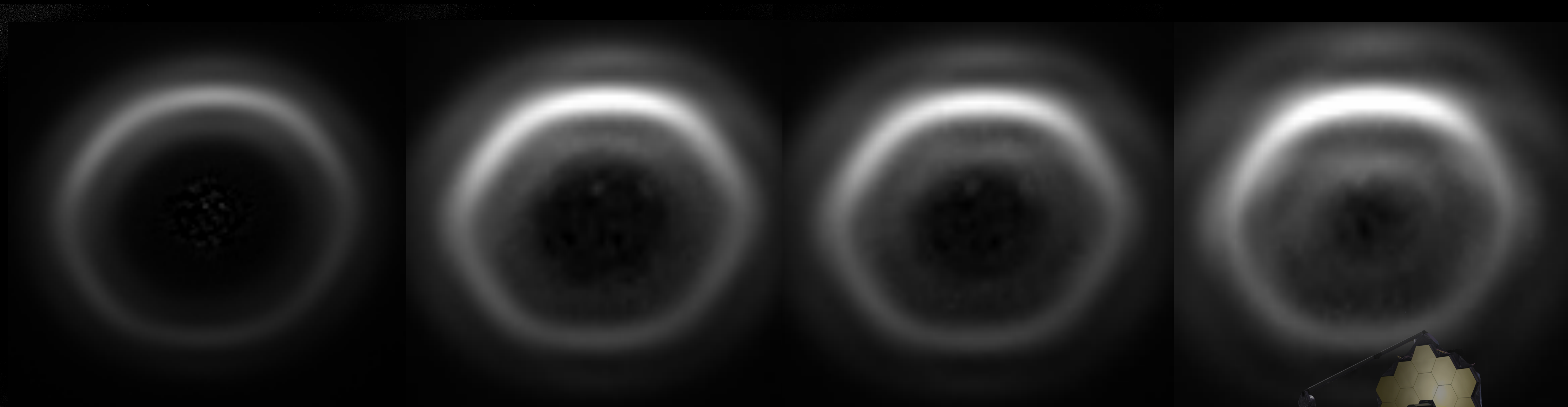
HD 181327

2.10 μm

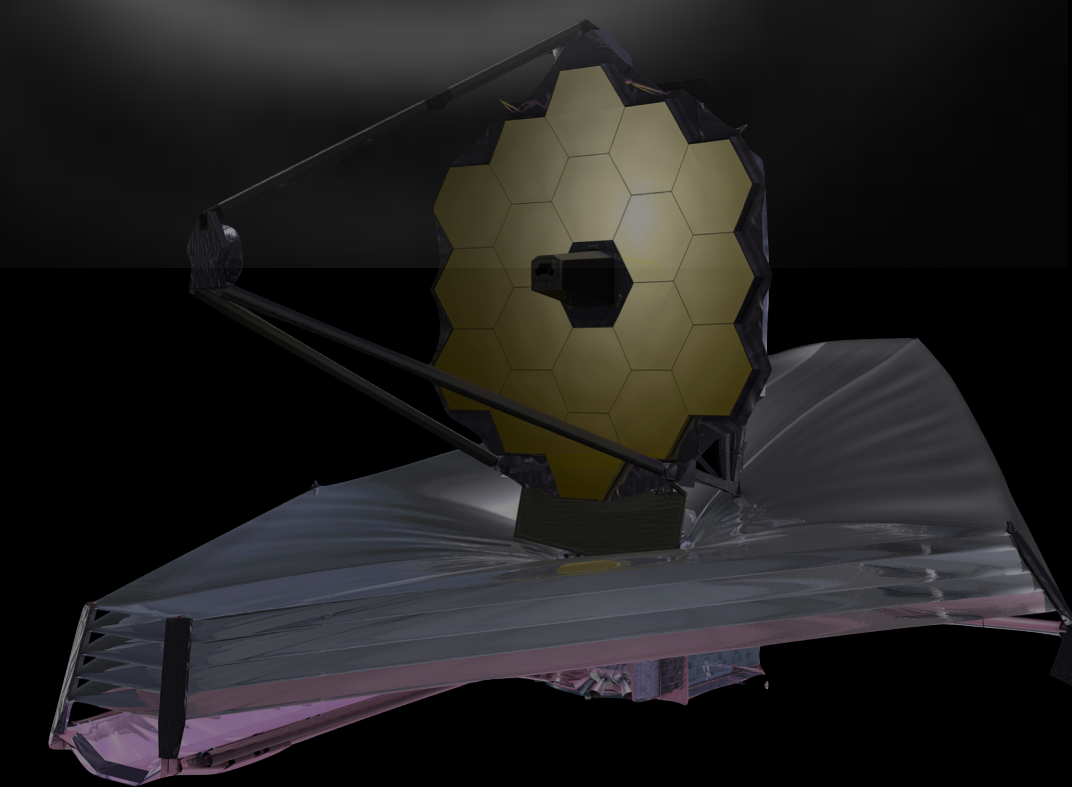
3.00 μm

3.35 μm

4.44 μm



(assuming an astronomical silicate mixture)



Summary

- There are a number of Cycle GTO programs for JWST that will observe a large number of debris disks!
 - NIRCам: 8 disks imaged across all programs; 5 within ours.
 - MIRI: 6 disks imaged across all programs; 3 within ours.
 - MIRI/NIRSpec: 10 systems studied spectroscopically
- MIRI will enable us to study the asteroid belts of the nearest systems! The data provided by MIRI will not be superseded by any observations in the foreseeable few decades! Our 25 h program will observe Fomalhaut, Vega, and ϵ Eri.
- NIRCам's sensitivity and stability will enable the study of dust composition and the locations of volatiles in the systems. Our 50 h program will observe HD 61005, HD 107146, HD 32297, HD 181327, and HD 10647.

